

The Center to Protect Workers' Rights

FINAL REPORT

REDUCING WORK-RELATED
MUSCULOSKELETAL DISORDERS
AMONG CONSTRUCTION WORKERS

DECEMBER, 1993

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I. Introduction

In October 1992, the Center to Protect Workers' Rights (CPWR) began a three year cooperative agreement with the National Institute for Occupational Safety and Health (NIOSH) to develop and implement a research project addressing work-related musculoskeletal disorders (WMD) among construction workers.

Specifically, the aims and objectives of the project are to:

- 1) Identify, through surveillance and field work, specific high risk trades and construction tasks which place workers at high risk on WMD,
- 2) Identify and test interventions which can help reduce the risk of injury, and
- 3) Explore the feasibility of a long-term longitudinal study of WMD among construction workers.

As detailed in its initial submission to NIOSH, the project consortium is headed by the Center to Protect Workers' Rights, the research arm of the Building and Construction Trades Department (AFL-CIO). The other consortium members include the University of Massachusetts at Lowell, the University of Iowa, the George Washington University Division of Occupational and Environmental Medicine and the George Washington University Biostatistics Center. (Note: Refer to original proposal for background and qualification descriptions for all consortium project team members.)

II. Background

Musculoskeletal disorders are common among construction workers. Recent NIOSH analyses of data from the 1988 National Health Interview Survey (NHIS) Occupational Health Supplement (Cameron, Behrens, Wild and Tanaka, 1993) show that:

* 5.3% of construction workers suffered from back pain due to injury over a 12 month period compared with 2.5% of all US workers. The highest rates were for carpenters (8.7%).

*10.1% had back pain due to repeated work activities compared with 4.5% of US workers. The highest rates were for brickmasons (25.5%).

*15.9% had severe hand discomfort compared with 10.7% of US workers. In some trades it is as high as 47.5% (structural metal workers).

Because of the severity of this problem, NIOSH has targeted musculoskeletal disorders among construction workers for additional research efforts. Teaming with NIOSH in October 1992, CPWR's project was structured to address WMD in construction workers at the local, regional and national levels, with an emphasis on the following program components:

- 1) **Surveillance** - to collect and use data on the prevalence of WMD in construction to help identify high risk groups and tasks for further study and intervention.
- 2) **Hazard Identification and Intervention** - to identify hazardous trades and tasks through a review of the literature, field work, qualitative and quantitative job tasks analyses and focus groups with workers and to pilot interventions in the workplace and monitor their efficacy. Ergonomics training is an important part of the interventions being piloted.
- 3) **Longitudinal Study of WMD among construction workers** - To begin assessing the feasibility of doing a longitudinal health study of work-related musculoskeletal disorders among a cohort of construction workers.

III. Progress Report (October 1, 1992--September 30, 1993)

A. Surveillance

The surveillance part of the project is being conducted on three levels: on a single project, on a state wide basis and on a national level.

1. Single Project--The project specific surveillance is being carried out by the University of Massachusetts at Lowell on a large highway construction project, the relocation of the Central Artery and construction of a third Tunnel (CA/T) in downtown Boston. Data on injuries and illnesses on that specific job are being collected and will be analyzed to look at incidence of WMD. Access to this project was granted in the Fall of 1993, so injury data has just begun to be collected by the project team.

While working out access arrangements with the Massachusetts Highway Department (MHD), building trades unions and site contractors, the project team gained access to an alternative MHD site in Plymouth, MA where

the techniques for studying ergonomics among highway construction workers were piloted. A detailed description of these activities is included in Tab 1.

2. State-wide--The State-wide surveillance data is being collected in the State of Iowa through admissions to hospital emergency rooms and through surveys of construction workers. The purpose of the Rural Injury Surveillance System (RISS) is to collect information on admissions to hospital emergency rooms in a designated part of the State.

Information on injuries and occupation is being coded and analyzed for all construction workers with WMD. Currently 10 hospitals are collecting data using the system, and data are just beginning to be analyzed. The University of Iowa is also conducting symptom surveys of construction workers throughout the state to help identify high risk groups or trades and the tasks they perform. Plans to distribute the survey to a larger cross-section of workers were delayed during the first grant year by administrative changes in the cooperating labor/management organization. A detailed report of this project can be found in Tab 2.

State-wide data are also being collected by George Washington University Biostatistics Center. Access has been granted to Workers Compensation data from the State of Washington and to the records of the Laborer's Union Health and Welfare Fund for Washington State. Comparisons are being made of the incidence of WMD in both data sets. Data from other construction union health and welfare funds, e.g., Painters and Bricklayers, are now becoming available for analyses as well.

3. National Data--National Data sets being reviewed include: Occupational Injury and Illness data from the Bureau of Labor Statistics (BLS), results of the National Health Interview Survey (NHIS) Occupation Follow-back in 1988, Workers Compensation data from the 1987 from the BLS Supplementary Data System (SDS), and health insurance data from Union Labor Life Insurance Company, which insures many union construction workers. A report on progress in collecting and analyzing these data sets is included in Tab 3.

In addition George Washington University is coordinating the collection of information on construction workers with WMD that are seen at Occupational Health Clinics throughout the US through the Association of Occupational and Environmental

Health Clinics (AOEC). Cases collected through the clinics network could act as sentinel events to identify associations between WMD and various trades or tasks. GWU is also conducting symptom surveys of some local unions in the Washington, DC area as part of this study and doing follow-up of several cases seen at their occupational health clinic. A detailed report on their work appears in Tab 4.

B. Hazard Identification and Intervention

The following approaches have been undertaken to identify high hazard jobs and tasks among construction workers, and to pilot interventions based on these findings.

1. Literature Review

Little research has been done on WMD's in construction, particularly in the US. What literature does exist was reviewed by the CPWR and developed into a publication for dissemination to construction workers and employers. This review will also be published in the May 1994 issue of the American Industrial Hygiene Association Journal. A pre-publication copy of this review appears in Appendix 5. In addition, the University of Iowa compiled 122 page annotated bibliography of abstracts of literature relating to musculoskeletal injuries in construction. A copy of the Iowa bibliography is included in Tab 2. Both the review and bibliography are being made available by the CPWR.

The literature review has been revised and updated to include new information since it was first drafted in Fall 1992. Additional literature was collected during Mr. Schneider's trip to Sweden in January. Information on WMD and the construction industry was collected and compiled to submit to OSHA in February 1993. Ninety-three articles were submitted along with comments from the Building and Construction Trades Department. Copies of these articles were then sent to each member of the consortium for their use in the WMD project, and to the University of Iowa to use in the development of their database of information on ergonomics in construction. The information resulted in the annotated bibliography published as described above. (see Tab 2).

This literature has helped the project team identify many of the high risk jobs in construction and identify candidates for further job analysis and for interventions.

Database Discussions were held at meetings of the consortium members in December 1992 and March 1993 on the need for a database of information on ergonomics in

construction (See position paper on databases in Appendix 19). The consortium agreed to establish a database of technical information at the University of Iowa as part of their current database on hazardous materials used in construction. The group also decided to explore setting up a widely accessible database of information on ergonomic hazards and solutions in the construction industry.

After exploring the development of a new development and various software programs which could handle the task, the team learned of a CD-ROM database being set up by the Canadian Center for Occupational Health and Safety (CCOHS) called "Solutions" which seemed to meet the requirements of the project (information on the system is attached). For each entry, information is presented about a safety and health problem and solutions which have been devised. Graphics can be included, which is essential to understanding ergonomic problems and solutions.

The Canadian Center's CD-ROM information system is widely used in the US and throughout the world. CD-ROM systems have become much less expensive in the past year and are becoming more common in both homes and offices. We have begun exploring with the Canadian Center and NIOSH developing an institutional relationship or cooperative agreement to put our data into the database and make it accessible to a large audience. A template for entering information into Solutions was obtained from the Canadian Center in Fall 1993 for distribution to consortium members (Appendix 10).

2. Focus Groups

Focus groups with workers have been held in Boston, Washington, Iowa and other cities around the US to get feedback from experienced workers about the hazards of their trade and ways to correct these hazards. A focus group script was developed for this activity by the University of Massachusetts at Lowell. A detailed report on the Lowell project is in Tab 1.

3. Surveys

Unions--A National Survey of Union Locals was already in process at the time of the WMD cooperative agreement award. An additional set of questions (attached at Appendix 3) was added to the survey and it was sent out to three hundred construction locals through one of the largest international unions (IBEW- International Brotherhood of Electrical Workers) across the country in Spring 1993. Fifty-eight percent returned the survey. The main ergonomic hazards varied some depending on the trade within the union. They

identified the top ergonomic hazards for members as: pulling cable and blocks/hoists, climbing, overhead work, heavy lifting, work on ladders/scaffolds, weather conditions, repetitive motions, and work on energized circuits.

The main ergonomic injuries identified were: back injuries, hand/wrist/carpal tunnel problems, shoulder injuries. They recommended the following solutions: better work practices, use of lifting devices, safer (more ergonomically designed) hand tools, training, protective clothing and a clean work area. The survey will be revised and will continue to be sent out through all the Building Trades affiliates and the results tabulated on an on-going basis as the grant continues. A copy of the survey results from the IBEW survey are in Appendix 3.

Contractors--Surveys of contractors have also begun with a survey of the members of the National Erectors Association to identify their knowledge or ergonomics and the extent of their programs to prevent ergonomic injuries. The survey was mailed to 160 contractors, with twenty-two returning completed responses. A copy of the survey and cover letter is attached in Appendix 4.

According to contractor responses received, back injury represented a third of all injuries and almost half of all costs. The survey revealed that contractors are clearly interested in ergonomics, have started some sort of programs to prevent these injuries, and are willing to spend more money on tools that could prevent injuries.

There was also a great interest in training on ergonomics. While contractor survey return rates were poor, it was a useful pilot. As a result of this effort a survey work group is planned for 1993-94. It will be a joint effort by all members of the consortium to help refine the questions before surveys are sent to more unions and contractors.

In addition a Washington Area Study Team has been set up in Washington, DC comprised of contractors, union representatives and researchers to collectively identify tasks and prioritize research efforts. They began meeting in September 1993. Appendix 11 includes copies of the survey forms and agendas and roster for the Washington Area Study Team.

Symptom and job risk factor surveys by the University of Iowa are also being used for hazard identification and will be disseminated in cooperation with contractors and unions in the Iowa/Illinois region.

4. Field Work

Field work is also an important part of the hazard identification program. Researchers are making site visits to construction sites to observe, record and analyze work postures and stresses during different types of construction work. Highway work is being observed in Boston on one of the largest highway projects in the US. The first site visit to the Boston project was in December 1993. Washington, DC is the site for office construction and renovation work. Iowa has smaller office construction and residential work. Other construction sites have been visited in California, Pennsylvania, and Maryland. In part these visits collected qualitative information on the types of work and risk factors present. Notes from these field visits are included in Appendices 11 and 12.

In addition, attempts are being made to quantify the hazards present through the use of video analysis (such as the Swedish ARBAN system for analyzing work postures) and a variation on the Finish OWAS work sampling system being used in Boston to look at percent time spent in various awkward postures. Laboratory studies, using electromyography, etc., are also planned for quantifying ergonomic risk factors associated with individual construction tasks at a new laboratory under construction at the University of Iowa.

Field investigations were originally expected to be conducted on a new construction site in Washington, DC which was to begin construction in November 1992. This building was never started and CPWR began looking for alternative sites.

CPWR identified five building sites in the Washington, DC area, one in Philadelphia, and several sites in California, which agreed to allow us access. The building sites in or near Washington included: Construction of a new office building (Geophysical Union) which started in March 1993, Renovation of the old Machinist's building (begun in Spring 1993), Construction on the Federal Triangle Building, Renovation of the new headquarters for National Public Radio, Construction of a new incinerator in suburban Maryland (begun in Spring 1993), A highway repair job in Maryland (Rt. 301 and Rt. 50).

The Philadelphia site involves construction of a parking garage. In California, several construction sites were identified by the Roofers Local Union (#95) in the area of San Jose.

CONSTRUCTION SITES IN WASHINGTON DC AREA

AMERICAN GEOPHYSICAL UNION- UNTIL 12/93
MACHINIST'S UNION FORMER HEADQUARTERS- UNTIL 12/93
NEW HEADQUARTERS NATIONAL PUBLIC RADIO-UNTIL 12/93
FEDERAL TRIANGLE OFFICE BUILDING- RODTYING
BRIDGE CONSTRUCTION AT Rt 301 AND Rt 50-RODTYING
DICKERSON INCINERATOR- INITIAL CONTACTS MADE
BLACK ENTERTAINMENT TELEVISION- VISIT PLANNED

As of the end of September 1993, visits have been made to all five Washington sites, the Philadelphia site and three sites in California. Work processes were videotaped on the three California sites. Time codes have been laid on a copy of the roofing videos to allow for frame by frame analysis using the Swedish ARBAN system. ARBAN is a system for postural analysis developed by Bygghälsan specifically for the construction industry and has been in use there for over ten years.

Videotapes were reviewed with Ira Janowitz, Ergonomist with the Spine Center in Oakland, CA, and the ARBAN method was used during an initial review the tapes. Observations from the site visits in California are summarized in the attached report (Appendix 12). Site visits to sites in Washington included observations of ductwork and drywall hanging, masonry work, drop ceiling installation, masonry and plumbing work. Notes on some of these field visits are included in Appendix 13 (Field notes on NPR visits for both September and October are included as they are combined). Extensive discussions have been held at Working Group meetings on Ergonomic Exposure Assessment (see position paper for March meeting in Appendix 19).

5. Piloting of New Tools

Not only are hazardous jobs being identified, but where solutions exist, interventions are being introduced on construction sites and piloted. This phase of the project is just beginning. New ergonomically designed tools are being taken out to sites and workers are being given the opportunity to try them out. The main tool that has been investigated so far has been a tool for rebar tying from Sweden.

Appendix 16 gives a detailed history of attempts to introduce this tool. Feedback will be solicited from the workers and symptom surveys may be used to see the impact of the intervention. An analysis of the success or failure of the intervention and factors that may influence successful intervention will be studied. Initially a survey will be made of workers reactions to the tool. A copy of the proposed survey is attached in Appendix 17. Analysis of the efficacy of different interventions will have to be tailored to the individual intervention. Ergonomic interventions will also be studied in the University of Iowa ergonomics laboratory under simulated conditions.

In addition the CPWR has taken a German ergonomically designed concrete block out on to a worksite in Washington, DC for discussions with workers laying blocks on that site. They were very interested in the block and enthusiastic about using it. The CPWR also had discussions or correspondence with several other tool manufacturers about testing out their equipment on worksites. The tools looked at include jackhammers with reduced vibration and iron rebar bending machines. The CPWR also contacted a physical therapist in Oregon who is promoting an pre-work program of stretching exercises for workers and one construction company which uses this program. A site visit to a construction site in California which incorporates this exercise program was conducted in October 1993.

Lastly, a book chapter in a compendium on Construction Safety and Health is planned which will discuss ergonomic interventions and how to introduce them in construction. It is titled "Ergonomics: Applying What We Know." It will be published in 1994.

6. Training

Training is considered an important part of any successful program. Training in ergonomics for construction workers are to be developed and piloted in Boston, Washington and Iowa. To date, Boston has developed a short awareness course and story boards for short tool box talks on ergonomics to be used on site and with apprentices. Copies of these sample story boards and an outline of the training is included in Tab 1. Washington is developing a short trigger video for use at local union meetings or apprenticeship classes to trigger discussions by workers of ergonomic risks and solutions. A draft script for the video is included in Appendix 7. Training is also being considered for supervisors and contractors.

In cooperation with NIOSH, the consortium has had extensive discussions on the development of training materials for

workers. Training materials on ergonomics in general and on ergonomics in construction have been collected, such as training videos, and distributed to the different consortium members. Discussions have focused on the content of the training, length of training, audience of the training and goals of training (see position paper on training in Appendix 19).

Generally training material development must occur after hazard identification, and so only preparatory work has been done on this part of the project. CPWR has also begun looking for training materials appropriate for contractors and union leaders, and has reached agreement with the Construction Safety Association of Ontario on safe materials handling (in particular, a new edition of their publication Stand, Lift and Carry) to distribute these materials.

The CPWR has held one formal training session with apprentices from the Plasterer's Union in Pittsburgh. CPWR has also held meetings with Local 201 of the Ironworker's Union in Washington, Local 3 of the Electrician's Union (IBEW) in New York, Local 95 of the Roofer's Union in San Jose, CA, and contractors in Philadelphia and Washington, DC to discuss the project and ergonomic problems in their trade.

A summary of the Plasterers training is attached as Appendix 14. One of the main purposes of the meeting and training is for the researchers to gain a better understanding of the construction process and those work tasks that the members feel are the most hazardous or deserve the most attention.

Contractor training will occur through presentations at national and regional meetings of contractors and safety professionals. Much of this will occur in year two of the grant. More training for contractors will be planned after we analyze the results of the national contractors survey.

7. Information Dissemination

Promotion/Publication--Information dissemination is another form of intervention. As more workers and contractors become aware of the risks and solutions, it could have an impact in reducing injuries on the job. A hazard information center and clearinghouse has been set up at the University of Iowa to collect information from the literature. As detailed in Section B.1, an annotated bibliography (Tab 2) has been published and will be updated periodically.

Additionally, in January 1993 the CPWR established an Information Dissemination Department within its offices. In

addition to the coordination of the National Conference (as described below), the Department edited and disseminated various reports published by CPWR throughout the grant year.

Specifically, a review of the ergonomic hazards of new construction by Scott Schneider and Pam Susie has been published (Report E1-1993) in February and widely disseminated. Over 800 copies have been printed and sent out. Press releases about the report have been published and sent to news organizations. Information about the report has appeared in the BNA Occupational Safety and Health Reporter. A revised version of report (Appendix 5) has also been accepted for May 1994 publication in the American Industrial Hygiene Association Journal (see letter in Appendix 5).

In addition to the written publication, presentations were made on ergonomics and construction to a special conference on Construction Safety and Health at the new Machinist's Union Headquarters (October 1992), the American Public Health Association 120th Annual Meeting (Nov. 1992), the Building and Construction Trades Department Legislative Conference (April 1993), and the American Industrial Hygiene Association Conference and Exposition (May 1993). Agendas for these meetings are appended (Appendix 6).

CPWR representatives also meet monthly with the Building and Construction Trades Department Safety and Health Committee and other organizations, such as the National Erectors Association/National Constructors Association Safety Committee, to share information about the project and data resulting from it. Additionally, CPWR has begun work on a short video (5-10 min) describing the problem in construction, the CPWR/NIOSH program, and information already known about solutions. A draft script is included in Appendix 7. The video is expected to be completed by January 1994.

Information will also be disseminated in the form of worker factsheets and through the CPWR Newsletter IMPACT (copies are included in Appendix 9).

In addition an information dissemination plan (which appears in Appendix 8) has been developed focused on summarizing the information in the Iowa database for several different audiences, such as International Union publications. For example, the data on ergonomic hazards for electricians will be summarized in an article slated for publication in the journal of the International Brotherhood of Electrical Workers (IBEW). In addition, talks on ergonomics and construction have been given for numerous audiences from professional meetings (like the American Public Health

Association and the American Industrial Hygiene Association) to union meetings (like the Roofers Union National Convention). Publications from the CPWR have been widely distributed. A recent publications list is attached in Appendix 21.

National Conference--A National Conference on Ergonomics, Safety and Health in Construction was held July 18-22, 1993 in Washington, DC. In CPWR's original proposal, we planned a conference solely on ergonomics for about 200 people. The conference was combined with a construction safety and health conference planned by the CPWR under a separate cooperative agreement with NIOSH. Ergonomics though was still a major focus of the conference, constituting about 1/3rd of the program. A copy of the program book is as Appendix 1.

NIOSH, OSHA and the Department of Energy co-sponsored the conference, contributing financial support in addition to active participation in the planning process. Over twenty thousand brochures were distributed about the conference. Ads for the conference were sent to over forty journals and about 20 union publications. Several articles/ads were published.

In addition, several other organizations signed on as supporters of the conference including: the National Erectors Association, the National Constructors Association, the American Public Health Association, the Society for Occupational and Environmental Health, the National Safety Council and the American Industrial Hygiene Association. Four foreign organizations also supported the conference: the Bau Berufsgenossenschaften from Germany, Bygghälsan from Sweden, the Stichting Arbouw from the Netherlands and the Construction Safety Association of Ontario from Canada.

The agenda was developed with the help of NIOSH, the other co-sponsors and the Safety and Health Committee of the Building and Construction Trades Department. In conjunction with the conference there was an exhibit of ergonomically designed tools for the construction industry and some new technology for health and safety in construction. A list of exhibitors is included in the program. A trip to Sweden in January helped identify potential exhibitors and solicit help from researchers in Sweden in putting the exhibit together. To solicit participation of American Tool Manufacturers, a letter of invitation was sent to over 100 members of the Hand Tool Institute. Letters were also sent to about 20 other companies we identified through discussions with people in the industry and in the field of ergonomics.

Over 750 people attended the conference, including government representatives, representatives from union, contractors, insurance representatives, and international visitors. The conference produced an "agenda for change" as summarized in 10 recommendations from Professor Dunlop who closed the conference. This recommendations are as Appendix 2, a press release from the conference. Conference proceedings will be published in January 1994.

The conference has generated many positive benefits already. One tool manufacturer who exhibited at the conference has, as a result of their experience there, set up an ergonomics committee at their company, and is reviewing how they could incorporate ergonomics in all their tool design.

Four regional conferences are planned for 1994 in Boston, Atlanta, Cincinnati and Seattle. A second National Conference will be held in Washington, DC in September 1995.

C. Longitudinal Study of WMD among construction workers

The third phase of this study is to investigate the feasibility of a longitudinal health study of WMD among construction workers. This is very difficult because of the transient nature of construction work and the wide variety of tasks performed by construction workers. Thus far, this part of the project has just been in the exploratory stages. The possibility of using Laborers in the Pacific Northwest as a cohort is being explored because of access to their health and welfare data. Iowa hopes to eventually achieve State-wide estimates of the prevalence of WMD among construction workers using their emergency room data or to expand their symptom survey to a national sample to get national estimates. These could be used for comparisons with a sample cohort.

IV. Organization

Personnel During the first grant year, the CPWR recognized the need for a full-time administrator for the WMD cooperative agreement and Scott Schneider was hired from the OHF beginning June 1, 1993 to manage the project. Prior to assuming this position, Mr. Schneider was spending a majority of his time on the WMD project while at the OHF. Mr. Schneider is charged with day-to-day management of the project, with specific duties including administration, field work, information dissemination, assisting with national surveys and helping with national and regional conferences.

Consortium/Project Team Meetings Throughout YEAR 1 CPWR has coordinated all aspects of the project, including the coordination of three meetings of the consortium members:

APPENDICES TO FINAL REPORT

- 1) National Conference Program Book
- 2) Press release with list of Recommendation from Dunlop to Conference
- 3) LU Survey questions on ergonomics- IBEW Survey, summary of results
- 4) NEA Survey and summary of results
- 5) Ergonomics and Construction review article and letter of acceptance from AIHA Journal
- 6) Agendas for WMD professional presentations during Year One
- 7) Draft script for ergonomics video
- 8) Dissemination plan for Iowa Center
- 9) Impact newsletter with ergonomics articles
- 10) Template for Solutions database
- 11) List of Washington Area Study Team Members and Agenda from 9/13 mtg.
- 12) Field notes from Roofing Site Visits in California
- 13) Field notes from Site Visits to NPR Site
- 14) Notes from Training for Plasterer's Apprentices in Pittsburgh
- 15) Notes from visit to Rodman's Local
- 16) Faxes exchanged with L. Lidman of GLIM re: Nanjomat
- 17) Draft Tool Evaluation Form
- 18) Agendas from WMD Consortium meetings
- 19) Position Papers on Training, Databases, Ergonomic Exposure Assessment and WMD Surveillance for March 1993 Working Group meetings in Lowell, MA
- 20) Agenda and Minutes from Ergonomics Subcommittee of CPWR Technical Advisory Board meeting July 21, 1993
- 21) CPWR Publications List

December in Washington, March in Lowell and June in Iowa. Agendas are included in Appendix 18. The purpose of these meetings has been to coordinate project efforts and educate one another based on our individual expertise. Also as Appendix 19 are copies of position papers on training, databases, ergonomic exposure assessment and WMD surveillance developed by CPWR/OHF and GWU Biostatistics Center for the March 1993 Working Group meetings. Representatives of NIOSH and others outside the consortium project team have participated in these meetings to share their expertise with the group. For example, Swedish experts presented Swedish data at the consortium meeting at Lowell in March 1993.

The overall impression from the participants has been that they have been very successful and grow more productive with each meeting as consortium members get to know each other better. They are planned to continue in the coming grant year with meetings in November (Cincinnati), February (Washington) and a third meeting in the summer.

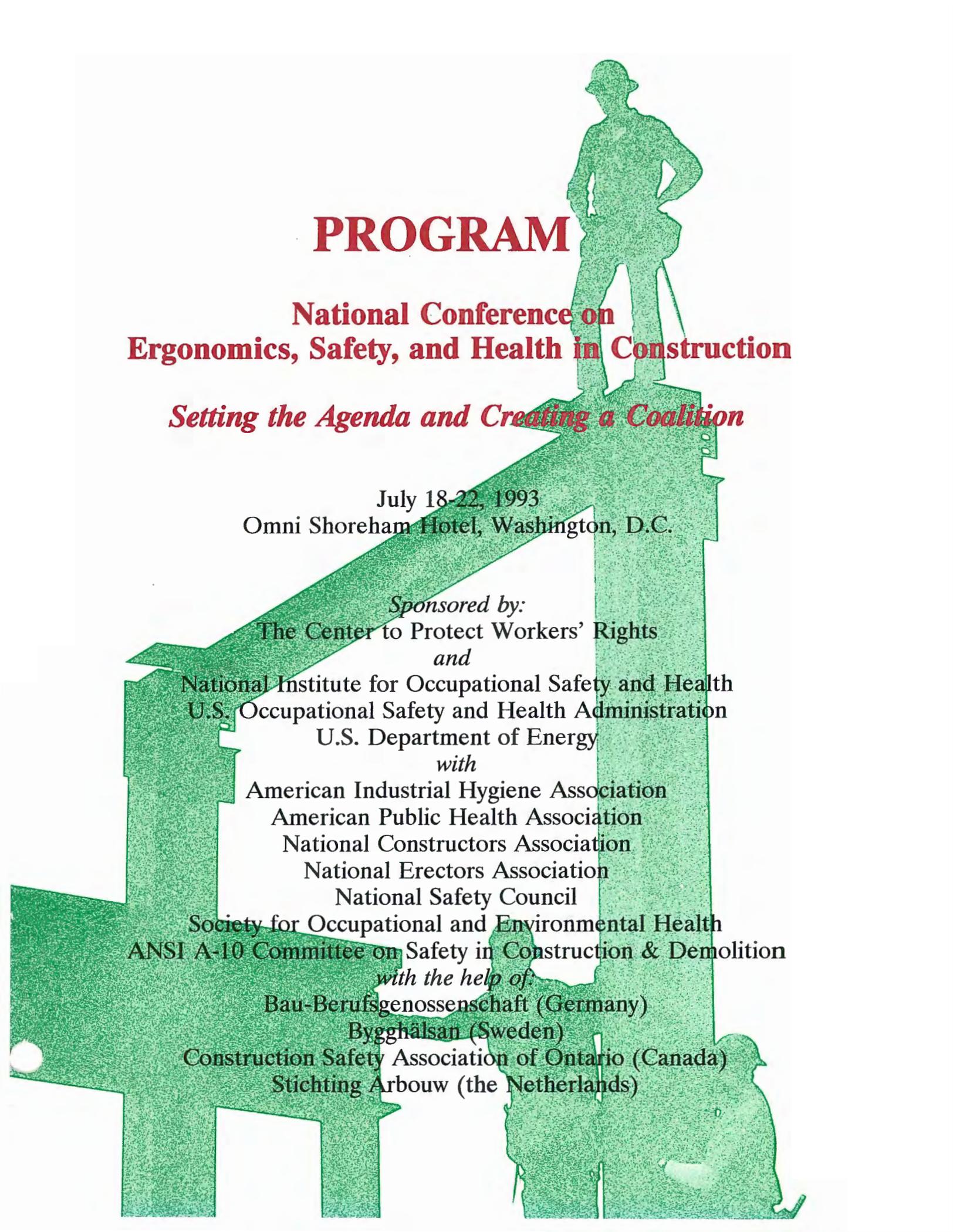
Advisory Board In addition, the CPWR has a Technical Advisory Board (TAB). The TAB meets quarterly and in 1993 formed an Ergonomics Subcommittee. The Subcommittee includes: Anders Englund (Sweden), Jerry Purswell (Oklahoma), Mike Smith (Wisconsin), Pete Stafford (CPWR), and (at the time) Barbara Silverstein (Washington State). Dr. Silverstein has since left the TAB as she took a new position with OSHA in November 1993. An agenda and minutes from the subcommittee's meeting in July 1993 is as Appendix 20.

V. Conclusion

The CPWR and its WMD Consortium has made good progress in Year 1 of its three year cooperative agreement. Working closely with NIOSH. The focus of Year 1 has been on surveillance and hazard identification/interventions. The project's level of activities will increase in Year 2, and the CPWR, working with NIOSH, has already begun to focus on long-term plans for Year 3 and beyond.

APPENDIX 1

National Conference Program Book



PROGRAM

National Conference on Ergonomics, Safety, and Health in Construction

Setting the Agenda and Creating a Coalition

July 18-22, 1993

Omni Shoreham Hotel, Washington, D.C.

Sponsored by:

The Center to Protect Workers' Rights
and

National Institute for Occupational Safety and Health
U.S. Occupational Safety and Health Administration
U.S. Department of Energy

with

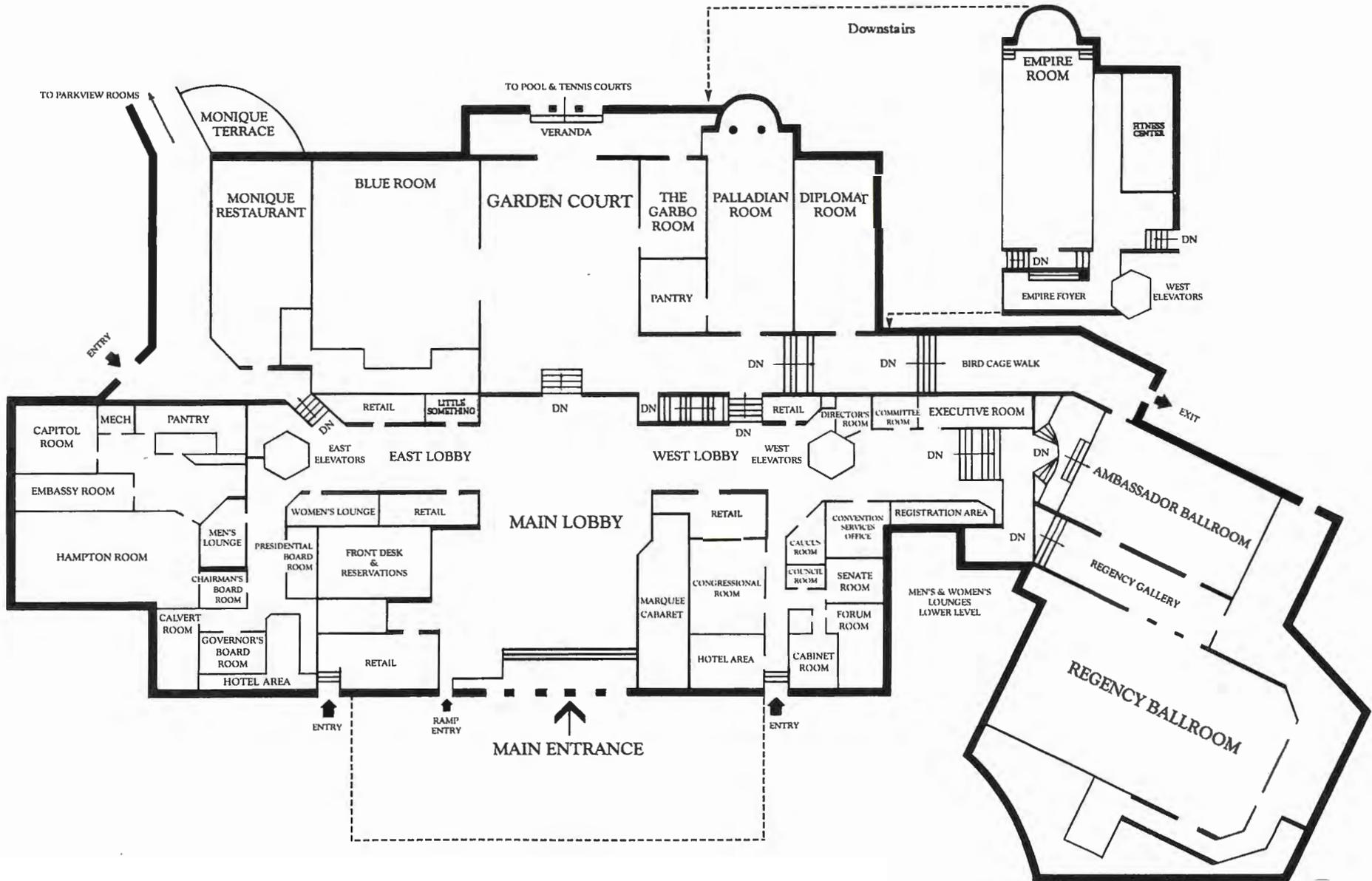
American Industrial Hygiene Association
American Public Health Association
National Constructors Association
National Erectors Association
National Safety Council

Society for Occupational and Environmental Health
ANSI A-10 Committee on Safety in Construction & Demolition

with the help of:

Bau-Berufsgenossenschaft (Germany)
Bygghälsan (Sweden)
Construction Safety Association of Ontario (Canada)
Stichting Arbouw (the Netherlands)

OMNI Shoreham Hotel Meeting Rooms



We are pleased to acknowledge financial support for this conference from the following organizations:

National Institute for Occupational Safety and Health

U.S. Occupational Safety and Health Administration

U.S. Department of Energy

Building and Construction Trades Department, AFL-CIO

Union Labor Life Insurance Company



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WELCOME!

This conference is a watershed for construction safety and health. It brings together unions, employers, government, public health advocates, construction owners, and insurance experts. Never before has such a broad range of interests assembled to address this subject.

This diverse gathering is as it should be. Safety and health should not be a source of dispute for the interests in the construction industry. We have a moral obligation that should be our primary motivation. If this fails, there is a legal framework — the Occupational Safety and Health Act — to fall back on. There is also an economic reason: Safety and health pays in reduced injuries and in lower construction costs.

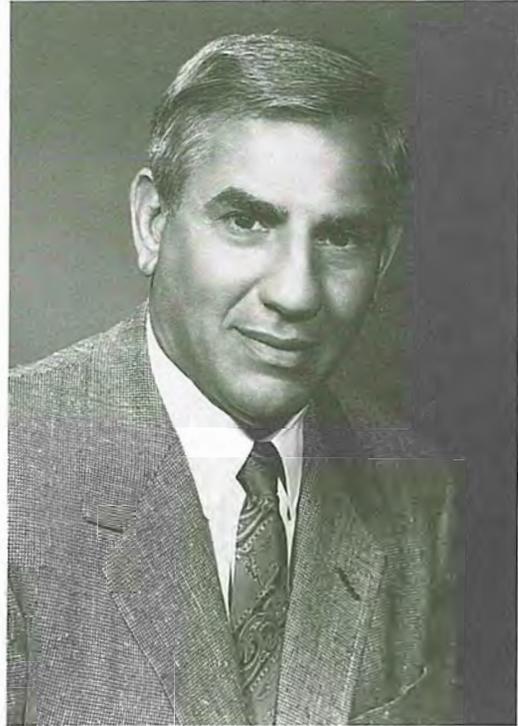
There is an epidemic in the United States, and it has to be stopped. It has been around for so long that no one seems to take notice. This epidemic is in the form of deaths, injuries, diseases, and disabilities among construction workers.

This week, some 40 construction workers will die on the job, some 4,000 will suffer serious injuries, and countless others will be exposed to hazards that will harm their health. We should remember this terrible toll as we meet.

The charge to this conference is clear. Our task is to define ways to control this epidemic, and this should be accomplished through consensus.

In the United States, we are in the unenviable position where we can learn from others who have advanced while we have stood still. We are grateful to the leaders of construction safety and health organizations in Germany, the Netherlands, Sweden, and Ontario, Canada. They have helped us define the needs and opportunities for change. They have brought their expertise to this conference.

This is a working conference. We want your involvement and input in shaping the national agenda to end the epidemic. That's what the workshops are for. We also hope you will stay with us as we follow up on your recommendations. Developing an agenda is one thing; implementing it is more difficult. For this we need a coalition, and we hope we are beginning here to build the coalition.



Robert A. Georgine
Conference Chairman

J. Donald Millar, M.D., D.T.P.H. (Lond.)
Director
National Institute for Occupational Safety and Health, CDC
July 13, 1981 - July 31, 1993



Dr. Millar has contributed greatly toward assuring safe and healthful working conditions for all America's workers. His accomplishments include promoting scientific excellence in NIOSH research, marshalling the program's resources to address the most significant, preventable workplace hazards, and supporting the reintroduction of worker safety and health activities into many state and local public health programs.

THANK YOU DR. MILLAR!

Schedule

Sunday, July 18

Noon-8:00 p.m.	Registration Begins West Lobby
3:00-6:00 p.m.	Exhibits First Open Ambassador Ballroom
6:00-8:00 p.m.	Opening Reception Veranda and Terrace (Blue Room is backup)

Monday, July 19

9:00 a.m. **Plenary Session I: Opening Session**
Regency Ballroom
Robert A. Georgine, Chair

Knut Ringen, Dr.P.H.
Director
Center to Protect Workers' Rights *Call to Order*

Robert A. Georgine
President
Building and Construction Trades Dept. *Welcome: Why We Are Here*

J.Donald Millar, M.D., D.T.P.H. (Lond),
Director
National Institute for Occupational
Safety and Health *Safety & Health: A New Beginning (video)*

Riley Bechtel
President and Chief Executive Officer
Bechtel Group *Welcome from NIOSH*

Riley Bechtel
President and Chief Executive Officer
Bechtel Group *Industry's Commitment to Safety and Health*

10:15 **Break and Exhibits**
Ambassador Ballroom

10:45 a.m. **Plenary Session II: Where the U.S. Stands**
Regency Ballroom
Robert A. Georgine, Chair

Vice President Albert Gore, Jr. (*tentative*) *The Clinton Agenda*

Anders Englund, M.D. (Panel Moderator)
Director, Dept. of Health & Social Affairs
National Board of Occupational Safety & Health
Sweden

Dr. jur Joachim Berger
Managing Director
Bau-Berufsgenossenschaft
Frankfurt, Germany

Leen Akkers
General Manager
Stichting Arbouw
The Netherlands

Matt Elliot
Immediate Past President
Construction Safety Assn. of Ontario *Organization of Safety & Health*

Monday Noon	<p>Lunch Blue Room</p> <p>Secretary Robert B. Reich (tentative):</p>	<i>The Department of Labor and Safety and Health in Construction</i>
1:30 p.m.	<p>Plenary Session III: The Magnitude of the Problem Regency Ballroom Irvin Etter, Chair</p> <p>Irvin Etter Executive Vice President & Chief Operating Officer National Safety Council</p> <p>John Moran, P.Eng. Director of Occupational Safety and Health Laborers' Health & Safety Fund of North America</p> <p>Eva Holmström, Dr.Med.Sci. Bygghälsan Sweden</p> <p>John Gentleman President Union Labor Life Insurance Co.</p>	<p><i>Overview</i></p> <p><i>Deaths and Traumatic Injuries</i></p> <p><i>Work-Related Musculoskeletal Disorders</i></p> <p><i>The Workers' Compensation Crisis</i></p>
3:00 p.m.	<p>Break and Exhibits Ambassador Ballroom</p>	
3:30 p.m.	<p>Plenary Session IV: Enforcement Strategies Jim Lapping, Chair (and Panel Moderator) Regency Ballroom</p> <p>James L. Weeks, Sc.D. Research Scientist George Washington University</p> <p>James P. Huckaby Director, Workers' Health & Safety Division Texas Workers' Compensation Commission</p> <p>David Ziegler Acting Assistant Secretary for Occupational Safety and Health U.S. Department of Labor</p> <p>James Conery B.E.C.E. Safety Administrator Boeing Corp.</p> <p>Wayne Rice Vice President and Manager of Safety Services Bechtel Construction Co.</p>	<p><i>Mining as a Model for Enforcement</i></p> <p><i>Prevention, Texas Style</i></p> <p><i>The View from OSHA</i></p> <p><i>An Owner's Viewpoint</i></p> <p><i>A Contractor's Viewpoint</i></p>

Tuesday, July 20

9:00 a.m.	Plenary Session V: Health Hazards Regency Ballroom Robert A. Georgine, Chair	
	James Melius, M.D., Dr.P.H. Director, Division of Occupational Health and Environmental Epidemiology New York State Department of Health	<i>Diseases in Construction</i>
	Reinhold Rühl, Dr.rer.nat., Dipl.chem. Specialist in Hazardous Materials Department of Occupational Safety and Health Bau-Berufsgenossenschaft	<i>The GISBAU System</i>
	Senator Tom Harkin	<i>The Americans with Disabilities Act and the National Construction Safety and Health Initiative</i>
10:15	Break and Exhibits Ambassador Ballroom	
10:45	Six Workshops on Safety and Health Hazards	
	William Burke, OSHA Ron Stanevich, NIOSH Mark Monson, Construction Safety Council Robert Dexter, Stone & Webster	<i>Shoring and Trenching</i> Diplomat Room
	Steve Cooper, Iron Workers Graciella Perez-Balke, OSHA Gwendolyn Cattledge, NIOSH Robert Krul, Roofers	<i>Slips, Trips, and Falls</i> Regency Ballroom
	Robert Herrick, NIOSH David May, OSHA Mike Andrews, Painters Laura Welch, George Washington University	<i>Solvents and Other Chemicals</i> Capitol Room
	John Moran, Laborers Paul Seligman, NIOSH Ellen Roznowski, OSHA Pam Susie, Center to Protect Workers' Rights	<i>Lead and Other Metals</i> Empire Room
	Dennis Groce, NIOSH L. Christine Oliver, Mass. General Hospital Bill Kojola, Laborers	<i>Dusts</i> Calvert Room

(Workshops—continued)

David Rall, Collegium Ramazzini
John Dement, Duke University Medical School
Marian F. Meiselman, Carpenters
Jack Keane, Asbestos Workers

Chrysotile Asbestos
Embassy Room

Noon

Lunch
Blue Room

Thomas P. Grumbly, Assistant Secretary for Environmental Restoration and Waste Management, U.S. Department of Energy: *DOE's New Vision*

1:30 p.m.

Plenary Session VI: Ergonomics
Regency Ballroom
Richard Lemen, Ph.D., Chair (and Panel Moderator)

Richard Lemen, Ph.D.
Deputy Director
NIOSH

Why Ergonomics is Important

Barbara Silverstein, Ph.D., M.P.H.
Research Director, SHARP Program
Washington State Department
of Labor & Industries

*What Has Been Done in the U.S. and
How It Pays Off*

Gerda Linke-Kaiser, Dr. med.
Chief, Industrial Medicine Service for the
Construction Industry & Building Trades
Bau-Berufsgenossenschaft
Frankfurt, Germany

*Ergonomic Innovations in Germany: Tile
Setters, Lifting, and Crane Operators*

Tony Cederqvist
Physiotherapist and Researcher
Bygghälsan
Sweden

*Ergonomic Innovations in Sweden:
Hands, Wrists, and Shoulders*

Nadine Marks, B.S.C.
Project Coordinator, Research and Development
Construction Safety Assn. of Ontario

Ergonomic Innovations in Canada

3:00

Break and Exhibits
Ambassador Ballroom

3:30

Four Workshops on Adopting Ergonomics in the Workplace

Lynn MacDonald, Sheet Metal Workers
LaMont Byrd, Teamsters
John Franks, NIOSH
Scott Schneider, Center to Protect Workers' Rights

Noise and Vibration
Palladian Room

(Workshops-continued)

Roger Nelson, Thomas Jefferson University
Gerda Linke-Kaiser, Bau-Berufsgenossenschaft
Tom Waters, NIOSH
Ira Janowitz, Univ. of California Ergonomics Lab.

Lifting
Diplomat Room

Stanley Hubbard, Electrical Workers
Harriet Applegate, Greater Cincinnati Occupational
Health Center
Roger Stephens, OSHA
Vern Putz-Anderson, NIOSH

Repetitive-Motion Injuries
Regency Ballroom

William Rhoten, Plumbers
Mark Catlin, Harborview Medical Center
Steve Shapiro, Environmental Protection Agency
Jean-Louis Belard, NIOSH

Heat Stress and Cold
Empire Room

6:00-8:00

Reception and Exhibits
Ambassador Ballroom

Wednesday, July 21

9:00 a.m.	Plenary Session VII: Prevention Regency Ballroom Philip J. Landrigan, M.D., Chair	
	Philip J. Landrigan, M.D. Chief, Department of Community Medicine Mt. Sinai School of Medicine	<i>The American Public Health Association and Construction Safety and Health</i>
	Steven I. Schlossberg Director, Washington Branch International Labor Organization	<i>The ILO Perspective</i>
	Philip R. Lee, M.D. Assistant Secretary for Health Dept. of Health and Human Services	<i>The Clinton Administration's Interest in Prevention</i>
	Margaret Seminario, M.S.I.H. Director, Occupational Safety and Health AFL-CIO (Moderator)	<i>Strategies for Prevention</i>
	Bill McCook, C.R.S.P. Training and Development Coordinator Program Delivery Group Construction Safety Assn. of Ontario	<i>Planning Site Safety and Health</i>
	Ake Lindblad Technical Director Bygghälsan Sweden	<i>Introducing New Technology</i>
	Paul Forder Vice-Chair, Labour Workplace Health and Safety Agency of Ontario	<i>Training</i>
10:15	Break and Exhibits Ambassador Ballroom	
10:45	Plenary Session VIII: Success Stories Regency Ballroom Thomas R. O'Neill, Chair	
	Manfred Heimann, Dipl.-Ing., Germany Pekka Roto, M.D., M.I.H., Finland J.C. den Nijs, the Netherlands	<i>Ending Sandblaster Silicosis Preventing Cement Dermatitis Reducing Lifting Injuries (Bags of Cement)</i>
	Göran Engholm, M.S.C., Sweden Eva Holmström, Dr.Med.Sci., Sweden	<i>Saving Workers' Hearing Reducing Rebar Tying Injuries</i>
Noon	Lunch Blue Room Senator Edward M. Kennedy: <i>OSHA Reform</i>	

1:30 p.m.	<p>Five Workshops on Implementing Safety and Health on the Worksite</p> <p>Richard Niemeier, NIOSH Stephen Mallinger, OSHA Ake Lindblad, Sweden Dan Paine, Sinco Matthew J. Burkart, ANSI A-10 Cttee.</p> <p>Ben Evans, ICF Kaiser Engineers Patrick Finn, DOE Diane Morrell, Ebasco Services John Moran, Laborers</p> <p>Clarence Atchison, Fletcher Industrial Mike Andrews, Painters Richard Dwyer, Carpenters Jerry Purswell, University of Oklahoma</p> <p>Sandra Tillett, Occupational Health Foundation Orlando Pannocchia, OSHA William Smith, Operating Engineers John Graham, Construction Safety Assn. of Ontario</p> <p>Ed Gorman, Carpenters Heinz Aulmann, HVBG Robert Nolan, U.S.A. Casualty Co.</p>	<p><i>How to Introduce New Technology</i> Capitol Room</p> <p><i>Managing Site Safety and Health</i> Diplomat Room</p> <p><i>The Role of Worker Training and Certification</i> Calvert Room</p> <p><i>Hazard Communication Programs</i> Regency Ballroom</p> <p><i>The Role of Workers' Compensation in Prevention</i> Empire Room</p>
3:00	<p>Break and Exhibits (last access to exhibits) Ambassador Ballroom</p>	
3:30	<p>Plenary Session VIII: Conference Report Regency Ballroom Robert A. Georgine, Co-Chair Robert McCormick, Co-Chair</p> <p>John Dunlop, Ph.D. Lamont University Professor Emeritus Harvard University</p>	<p><i>Personal Observations and Conference Findings</i></p>
4:30	<p>Main conference ends</p>	

Thursday, July 22

**Special Session on Workers' Compensation
Empire Room**

9:00 a.m

Plenary Session: Defining the Problem

Joseph F. Maloney, Co-Chair

Noel Borck, Co-Chair

Arthur Oleinick, M.D., J.D., M.P.H.

Associate Professor

School of Public Health

University of Michigan

*The Magnitude of the Problem: What the
Data Show*

John H. Lewis

Attorney

Coconut Grove, Florida

*The State of Workers' Compensation in
the United States*

Kevin Ryan, F.C.A.S., M.A.A.A.

Director, National Property & Casualty

Insurance Services

Cooper & Lybrand

Wayne, Pa.

Assigned Risk Pools

10:15

Break

10:45

Anders Englund, M.D. (Panel Moderator)

Director, Dept. of Health & Social Affairs

National Board of Occupational Safety & Health

Sweden

Matt Elliot

Immediate Past President

Construction Safety Assn. of Ontario

*Handling Cross-Craft and Multi-Employer
Issues*

Joachim Berger, Dr.jur.

Managing Director

Bau-Berufsgenossenschaft

Frankfurt, Germany

and

Heinz Aulmann, Dr.jur.

Head, Department of Accident Insurance Law and

International Affairs

HVVG

St. Augustin, Germany

Funding by Sector

J.F.A. Letteboer

Deputy Director

Stichting Arbouw

The Netherlands

Integrating the System

Thursday, July 22
Special Session on Needs for Research

9:00 a.m.

Plenary Session: Defining the Problems
Ambassador Ballroom
Richard Lemen, Ph.D., Chair

Richard Lemen, Ph.D.
Deputy Director
NIOSH

The Need for More and Better Research

John Finklea, M.D., Dr.P.H.
Medical Officer
Center to Protect Workers' Rights
Centers for Disease Control & Prevention

*Conference Research Issues and Linking
Research Intervention and Evaluations*

Göran Engholm, M.S.C.
Bygghälsan

Overview of Epidemiology

Timothy Ore, Ph.D.
Manager, policy and economic analysis
TCF Development Authority
Melbourne, Australia

*Trends and Costs of Injuries and Disease
in the New South Wales Construction
Industry*

Arthur Oleinick, M.D., J.D., M.P.H.
Associate Professor
Dept. of Environmental and Industrial Medicine
University of Michigan

*Using Workers' Compensation Data in
Research*

G. Stewart Young, M.H.S.
Central Artery/Tunnel Safety Consultant
Arthur D. Little Inc.

Monitoring a Construction Project

10:15

Break

(Special session on needs for research-continued)

10:45

Three Workshops

Safety and acute trauma

Thomas Bender, M.D., M.P.H., NIOSH, Chair
Richard Niemeier, Ph.D., NIOSH, Rapporteur
Ambassador Ballroom

Health hazards

Philip Bierbaum, M.E., NIOSH, Chair
Nancy Bollinger, M.S., Rapporteur
Executive Room

Ergonomics (musculoskeletal exposures), noise, and worksite culture

Lawrence Fine, M.D., Dr.P.H., NIOSH, Chair
Derek Dunn, Ph.D., NIOSH, Rapporteur
Diplomat Room

Noon

Lunch (with workers' compensation session participants)

Regency Ballroom

Jay Himmelstein, M.D., Assistant Chancellor for Health Policy, University of
Massachusetts Medical Center, Worcester

*Workers' comp, health care reform, and ADA: Problems of Integration and Research
Needs*

1:30 p.m.

Workshops continue

3:30

Break

(in workshop rooms)

4:00

Plenary Session: Reports by Three Workshops

Ambassador Room

Chair, James Merchant, M.D., Dr.P.H.

Richard Niemeier, Ph.D.

Safety and acute trauma

Nancy Bollinger, M.S.

Health hazards

Derek Dunn, Ph.D.

Ergonomics, noise, and worksite culture

4:30

Session ends

**Special Session on Research Needs
Safety and Acute Trauma Workshop
Ambassador Ballroom**

Chair: Thomas Bender, M.D., M.P.H., NIOSH
Rapporteur: Richard Niemeier, Ph.D., NIOSH

Injury Surveillance (75 minutes)¹

Presenters

Timothy J. Pizatella
NIOSH

Surveillance of Fatalities

William Eisenberg
Bureau of Labor Statistics

*Morbidity and Mortality Surveillance in
Construction in the U.S.*

Discussant

Earl Pollack, Sc.D.
George Washington University

Presenters

D.L. McVittie, D.Eng.
Construction Safety Assn. of Ontario

Construction Injury Surveillance in Ontario

Paul Becker, M.S., C.I.H.
West Virginia Construction Safety & Health Program

Construction Injury Surveillance at the State Level

Robert Brewer, M.D.
National Center for Injury Prevention & Control

Hospital-Based Injury Surveillance

Discussant

Diane Wagener, Ph.D.
National Center for Health Statistics

Discussion from the floor (25 minutes)

Epidemiology of Workplace Injuries (50 minutes)

Presenters

Harlan Amandus, Ph.D.
NIOSH

Injury Risk Factors and Data Collection Methods

Terence Chorba, M.D., M.P.H., M.P.A.
National Center for Injury Prevention & Control

Record Linkage

Discussants

Craig Zwerling, M.D., Ph.D., M.P.H.
University of Iowa

Carol Conroy, M.P.H., Ph.D.
Univ. of California Health Dept.

¹Presenters have 10 minutes each and discussants 5 minutes each.

(Safety and acute trauma workshop—continued)

Discussion from the floor (20 minutes)

Intervention/Control Research (55 minutes)

Presenters

Aaron Schopper, Ph.D.
NIOSH

Engineering Interventions

Jorma Saari, Ph.D.
Finnish Institute of Occupational Health

Behavioral Interventions

Janet Johnston, Ph.D.
NIOSH

Training

Discussants

Pat Cattafesta
OSHA

Ralph Frankowski, Ph.D.
University of Texas

Discussion from the floor (15 minutes)

Special Session on Research Needs Health Hazards Workshop

Chair: Philip Bierbaum, M.E.
Rapporteur: Nancy Bollinger, M.S.

Opening Remarks

Nancy Bollinger, M.S.
NIOSH

Leading Work-Related Diseases in Construction (35 minutes)

Presenter (10 minutes)
Philip Bierbaum, M.E.
NIOSH

What We Know Now

Discussants (5 minutes)
James Nethercott, M.D.
Johns Hopkins University

Dermatology

Paul Schulte, Ph.D.
NIOSH

Cancer

L. Christine Oliver, M.D.
Massachusetts General Hospital

Lung Diseases

Laura Welch, M.D.
George Washington University

Reproductive Disorders

Edward L. Baker, M.D., M.P.H.
Centers for Disease Control and Prevention

Neurotoxic Disorders

Discussion from the floor (time permitting)

Industrial Hygiene and Exposure Assessment: Research Needs (35 minutes)

Presenters (10 minutes each)
Robert Herrick, Sc.D., C.I.H.
NIOSH

Sampling and Analysis

Sidney Soderholm, Ph.D.
NIOSH

Aerosols

Discussants (5 minutes each)
Mark Goldberg, Ph.D.
Mt. Sinai School of Medicine

John Dement, Ph.D.
Duke University Medical School

Dennis W. Groce, C.I.H.
NIOSH

Discussion from the floor (time permitting)

(Health hazards workshop—continued)

Lunch

Health Effects: Research Needs (50 minutes)

Presenters (10 minutes each)

William Halperin, M.D.
NIOSH

Morbidity Surveillance

Cynthia Robinson, Ph.D.
NIOSH

Mortality-Based Epidemiology

Paul Seligman, M.D., M.P.H.
NIOSH

Clinic-Based Approaches

Discussants (5 minutes each)

Elizabeth Grossman, Sc.M.
OSHA

Discussion from the floor (15 minutes)

Break (5 minutes)

Controlling Exposures: Research Needs (40 minutes)

Presenters (10 minutes each)

James Jones, C.I.H.
NIOSH

Engineering Controls

James Spahr, M.P.H.
NIOSH

Personal Protective Equipment

Cor van Duizenbooden, M.D.
Stichting Arbouw

Controlling Solvent Exposures among Painters

Discussant (5 minutes)

Robert Spear, Ph.D.
University of California

Discussion from the floor (5 minutes)

OSHA's View: Research Needs for Construction Safety and Health (20 minutes)

Presenter (10 minutes)

TBN
OSHA

(Health hazards workshop—continued)

Discussants (5 minutes each)

Pam Susie, M.S.P.H.

Center to Protect Workers' Rights

Worker Viewpoint

Aronne Goldkette

Broad, Vogt & Conant Inc.

Employer Viewpoint

Summary Comments (5 minutes)

Nancy Bollinger, M.S.

Special Session on Research Needs
Workshop on Ergonomics (Musculoskeletal Exposures), Noise, and Worksite Culture
Diplomat Room

Chair: Lawrence J. Fine, M.D., Dr.P.H.
Rapporteur: Derek Dunn, Ph.D.

Presenters

Work-Related Musculoskeletal Disorders

- | | | |
|----------|--|--|
| 11:00 am | Lawrence J. Fine, M.D., Dr.P.H.
NIOSH | <i>Welcome and NIOSH Perspective on Work-Related Musculoskeletal Disorders</i> |
| 11:05 | Eva Holmström, Dr.Med.Sci.
Bygghälsan | <i>Low-Back Disorders</i> |
| 11:20 | Barbara Silverstein, Ph.D., M.P.H.
Washington Dept. of Labor & Industries | <i>Upper Extremity Disorders</i> |
| 11:30 | Thomas Cook, Ph.D., P.T.
University of Iowa | <i>Control Strategies</i> |
| 11:40 | Martin Helander, Ph.D.
University of Buffalo | <i>Control Strategies</i> |
| 11:50 | Amit Bhattacharya, Ph.D.
University of Cincinnati Medical Center | <i>Directions for Future Research</i> |

Noon **Lunch**

Noise

- | | | |
|---------|---|-------------------------------|
| 1:30 pm | Lawrence J. Fine, M.D., Dr.P.H.
NIOSH | <i>Introduction</i> |
| 1:35 | Derek Dunn, Ph.D.
NIOSH | <i>Adverse Health Effects</i> |
| 1:50 | Dennis Driscoll, M.S., P.E., INCE Bd.Cert.M.S.
Associates in Acoustics | <i>Adverse Health Effects</i> |

Worksite Culture

- | | | |
|------|---|--|
| 2:00 | Susan J. Schurman, Ph.D.
Rutgers University | <i>Effective Prevention: Changing Behavior and Organizations</i> |
| 2:10 | Jeffrey V. Johnson, Ph.D.
Johns Hopkins University School of Public Health | <i>Effective Prevention: Changing Behavior and Organizations</i> |

(Workshop on ergonomics, noise, and worksite culture—continued)

Discussants

- 2:25 Scott Schneider, M.S., C.I.H.
Center to Protect Workers' Rights
- 2:40 Roger Stephens, Ph.D.
OSHA
- 2:50 Stephen Burastero, M.D., M.P.H.
Lawrence Livermore National Laboratory

Audience Comment

3:00-3:30

Continuing Medical Education Credits, Continuing Education Units, and Certification Maintenance Points

The U.S. Centers for Disease Control and Prevention is offering 20 CME and 2 CEU credits to individuals who qualify. To obtain credit, complete an evaluation form following each session and leave the form in a designated box when exiting the session.

The American Board of Industrial Hygiene will award 3.0 CMPs to certified industrial hygienists attending July 19-21 — 0.5 CMP for each half day — and 1.0 CMP for attending the special session on research needs Thursday, July 22. The ABIH approval number is 7593. Ask at the registration desk for a copy of the letter indicating ABIH approval.

Speakers

Abbreviations and Translations

AFL-CIO	— American Federation of Labor & Congress of Industrial Organizations
CDC	— U.S. Centers for Disease Control and Prevention
BCTD	— Building and Construction Trades Department, AFL-CIO
NIOSH	— National Institute for Occupational Safety and Health, CDC
OSHA	— U.S. Occupational Safety and Health Administration, Department of Labor
BBG	— Bau Berufsgenossenschaft, The Building Industry's Foundation, Germany
Bygghälsan	— The Swedish Construction Industry's Organization for Working Environment
Stichting Arbouw	— Dutch National Foundation for Health, Safety, and the Prevention of Absenteeism in the Construction Industry

Leen Akkers, general manager, Stichting Arbouw, Amsterdam

Harlan Amandus, Ph.D., chief, Analysis and Field Evaluations Branch, Division of Safety Research, NIOSH, Morgantown, W.Va.; author, *The Epidemiology of Workplace Injuries: The Contribution of Causality Research*, 1993

Mike Andrews, health and safety representative, International Brotherhood of Painters and Allied Trades, Washington, D.C.

Harriet Applegate, director, Greater Cincinnati Occupational Health Center

Clarence Atchison, safety director, Fletcher Industrial Construction; formerly with Washington State Department of Labor and Industries

Heinz Aulmann, Dr.Jur., chief, Department of Accident Insurance Law and International Affairs, Hauptverband der gewerblichen Berufsgenossenschaften, St. Augustin, Germany

Edward Baker, M.D., M.P.H., director, Public Health Practice Program Office, CDC, Atlanta; formerly deputy director, NIOSH

Amit Bhattacharya, Ph.D., associate professor of environmental health and industrial engineering, Department of Environmental Health, University of Cincinnati Medical School; now studying ergonomic issues among Carpenters

Riley Bechtel, president and chief executive officer, Bechtel Group Inc.

Paul Becker, M.S., C.I.H., director, West Virginia Construction Safety and Health Program, Morgantown

Jean-Louis Belard, visiting scientist, Division of Safety Research, NIOSH, Morgantown, W.Va.; formerly secretary, Ergonomics and Human Factors Coordination Group, French Ministry of Defense

Tom Bell, Jr., director of compensation, Ohio AFL-CIO

Thomas Bender, M.D., M.P.H., director, Division of Safety Research, NIOSH

Joachim Berger, Dr. jr., managing director, BBG, Frankfurt, Germany

Philip J. Bierbaum, M.E., director, Division of Physical Sciences and Engineering, NIOSH, Cincinnati

Nancy Bollinger, M.S., deputy director, Division of Respirator Disease Studies, NIOSH, Morgantown, W.Va.

Noel Borck, executive vice president, National Erectors Association, Arlington, Va.

Robert Brewer, National Center for Injury Prevention and Control, CDC, Atlanta

Steve Burastero, M.D., M.P.H., director, clinical services and ergonomics, Lawrence Livermore National Laboratory, Livermore, Ca.

Matthew J. Burkart, P.E., B.S.C.E., chair, ANSI A-10 Committee, Construction Safety & Health Standards, and president, Aegis Corp., Southampton, Pa.

William A. Burke, assistant area director, OSHA, Dallas; formerly construction safety specialist, Office of Construction and Engineering, OSHA

Lamont Byrd, industrial hygienist, International Brotherhood of Teamsters, Washington, D.C.

Mark Catlin, director and industrial hygienist, Washington Committee on Occupational Safety and Health, Seattle; author, "Labor-Based Pollution Prevention Initiatives," in: *Pollution Prevention Integration: A Practical Guide for State and Local Government*, 1993.

Gwendolyn Cattledge, M.S.E.H., Ph.D., epidemiologist, NIOSH, Morgantown, W.Va.; co-author of CDC publications on injury prevention and formerly epidemiologist, Graduate School of Public Health, University of Pittsburgh.

Pat Cattafesta, C.S.P., P.E., M.B.A., safety engineer, OSHA, Washington, D.C.

Tony Cederqvist, physiotherapist and researcher, Bygghälsan

Terence Chorba, M.D., M.P.H., M.P.A., acting associate director for science, Division of Unintentional Injury Prevention, National Center for Injury Prevention and Control, CDC, Atlanta

James R. Conery, B.E.C.E. construction administrator, Boeing Corp., Seattle; member A.S.S.E., Puget Sound Safety Summit Committee, and Safety Subcommittee for Northwest Construction Consumer Council

Carol Conroy, M.P.H., Ph.D., occupational epidemiologist, California Public Health Foundation, Berkeley; co-author of CDC reports on injury prevention

Thomas Cook, Ph.D., P.T., associate professor and director, Biomechanics/Ergonomics Laboratory, University of Iowa, Iowa City

Steve Cooper, P.E., safety director, Iron Workers' International Union

John Dement, Ph.D., associate professor of industrial hygiene/epidemiology, Duke University Medical Center, Division of Occupational and Environmental Medicine; formerly associate director for prevention, National Institute of Environmental Health Sciences and supervisor of the Hazardous Waste Worker Training Program

Jan C. den Nijs, deputy director, Stichting Arbouw, Amsterdam

Robert Dexter, assistant manager, environmental safety and health, Stone & Webster Engineering, Boston

Dennis Driscoll, M.S., P.E., INCE Bd.Cert., president and principal consultant, Associates in Acoustics, Dallas; also member, Executive Council, National Hearing Conservation Assn., and board member, Council for Accreditation in Occupational Hearing Conservation

John T. Dunlop, Ph.D., Lamont University Professor Emeritus, Harvard University and chair, U.S. Commission for the Future of Worker-Management Relations; formerly U.S. secretary of labor, 1975-76; author, *Industrial Relations Systems*, rev.edn., 1993.

Derek Dunn, Ph.D., deputy director, Division of Biomedical and Behavioral Science, NIOSH, Cincinnati

Richard Dwyer, Ed.D., director of training and education, Carpenters' Health and Safety Fund of North America, Washington, D.C.

William Eisenberg, assistant commissioner, Office of Safety, Health and Working Conditions, Bureau of Labor Statistics, U.S. Department of Labor

Donald E. Elisburg, J.D., counsel, Laborers-Employers Cooperation and Education Trust and Laborers' Health and Safety Fund N.A.; formerly assistant secretary of labor for employment standards and also general counsel and staff director, U.S. Senate Committee on Labor and Human Resources.

James N. Ellenberger, assistant director, Dept. of Occupational Safety and Health, AFL-CIO

Matt Elliot, assistant construction director, Teamsters Canada; immediate past president, Workplace Health and Safety Agency of Ontario

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Paul Forder, vice-chair, labour, and joint chief executive officer, Workplace Health and Safety Agency, Ontario, Canada; formerly United Auto Workers Local 444 (now Canadian Auto Workers) and director of organization services, Ontario Federation of Labour

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John Franks, Ph.D., NIOSH

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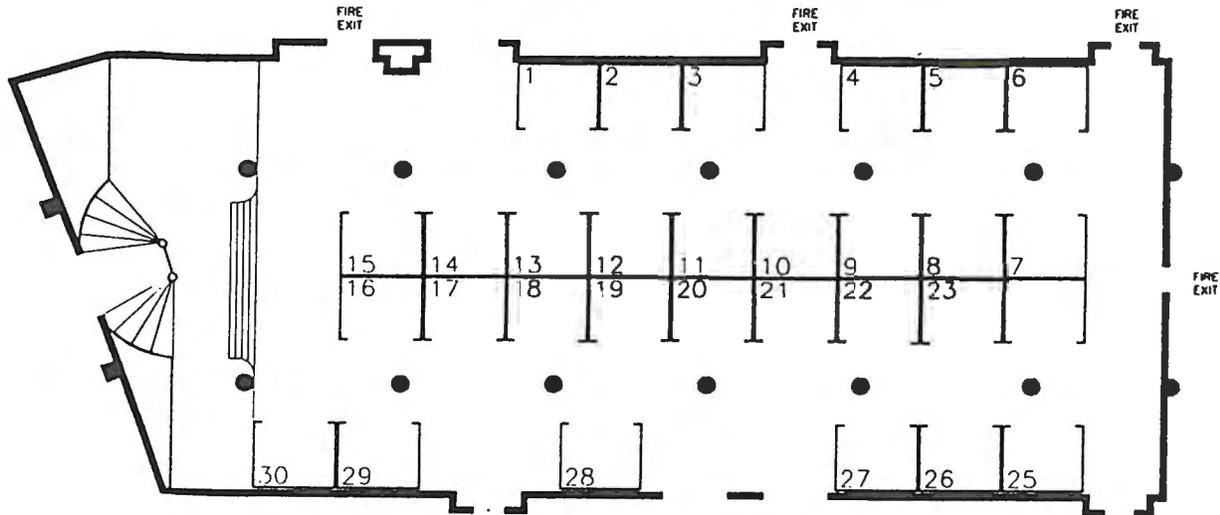
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Craig Zwerling, M.D., Ph.D., M.P.H., associate director, University of Iowa Injury Prevention Research Center, Iowa City

Exhibit Locations

Ambassador Ballroom



Exhibitors

Bilsom	Booth 1
American Industrial Hygiene Association	Booth 2
National Safety Council	Booth 3
Department of Energy	Booth 4-6
Ingersoll-Rand Company	Booth 7-8
National Constructors Association	Booth 9
National Erectors Association	Booth 10
NIOSH Cooperative Agreements: Model State-Wide Construction Safety and Health Programs, West Virginia University, State University of New York at Buffalo, Chicagoland Construction	Booth 11
Scandinavian Ergonomic Equipment and Tools	Booth 12-18
International Labor Office	Booth 19
Sandvik Saws & Tools Co.	Booth 20
Union Labor Life Insurance Company	Booth 21
Occupational Safety and Health Administration	Booth 22
Slip Industries	Booth 23
Construction Industry Ergonomics Database, University of Iowa	Booth 25
The SINCO Group	Booth 26
Professional Safety Consultants/University of Maryland Critical Path Management/Safety and Health	Booth 27
National Institute for Occupational Safety, and Health, CDC/Center to Protect Workers' Rights	Booth 28
Sullair Corporation	Booth 29
Construction Safety Association of Ontario	Booth 30

Exhibit Times

Exhibits Open	Sunday, July 19	3 - 6 pm
	Monday, July 20	8 - 9 am, 10:15 - 10:45 am, 3 - 3:30 pm
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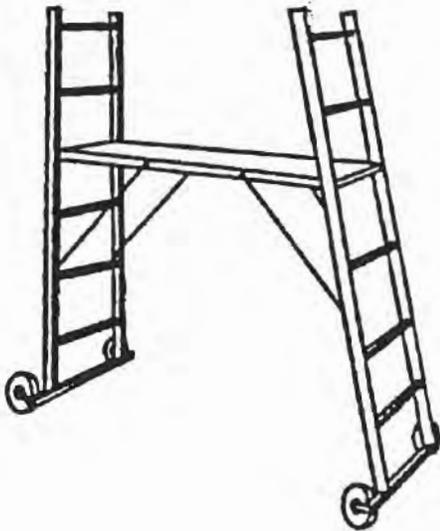
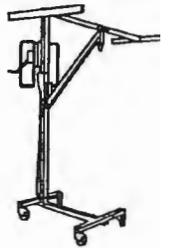
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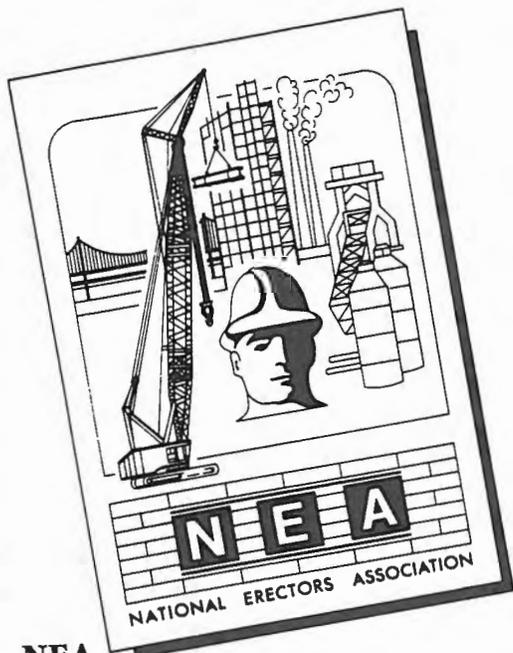
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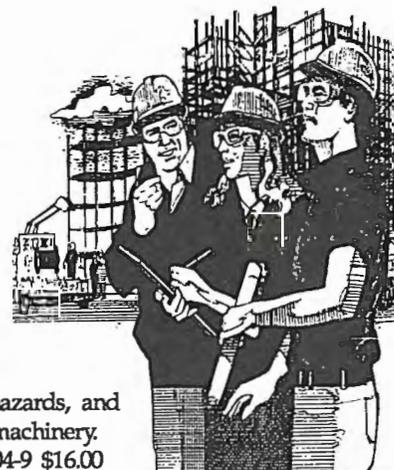
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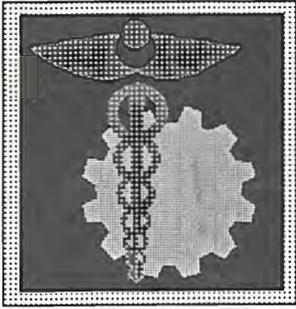
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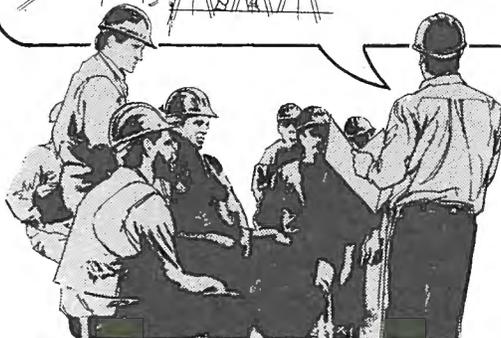
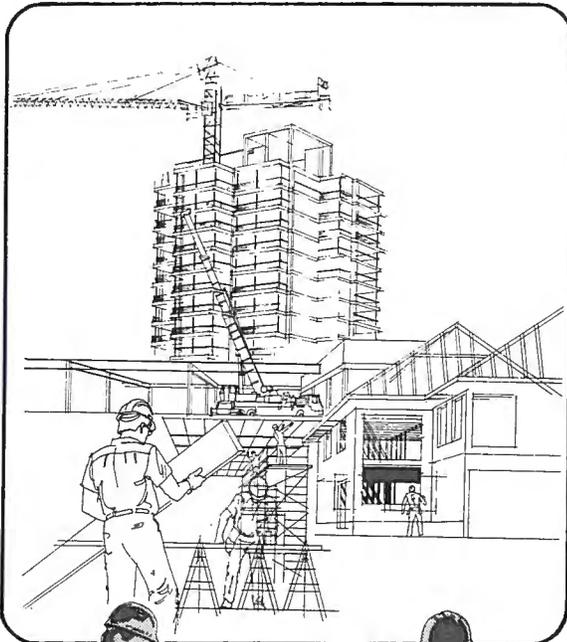
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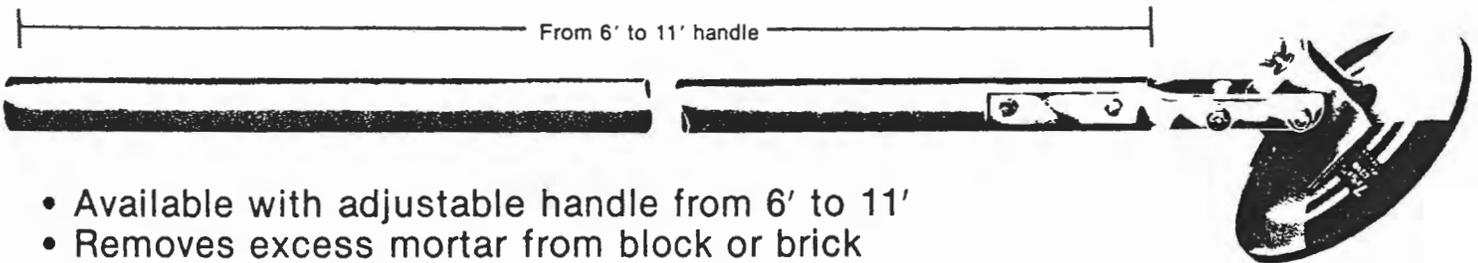


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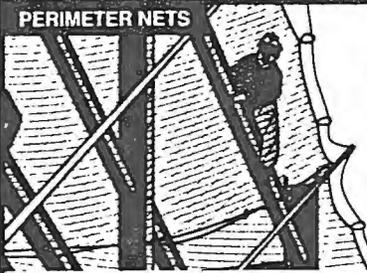


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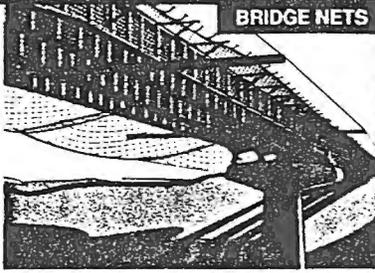


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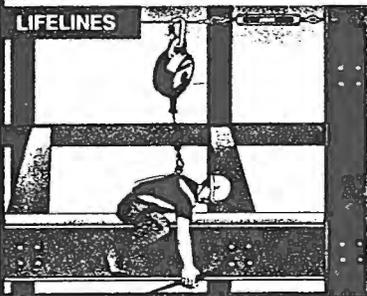
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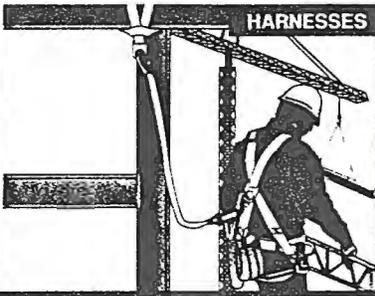
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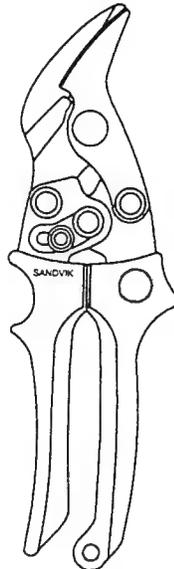
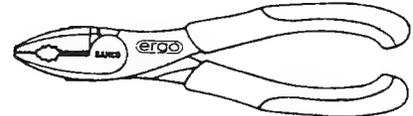
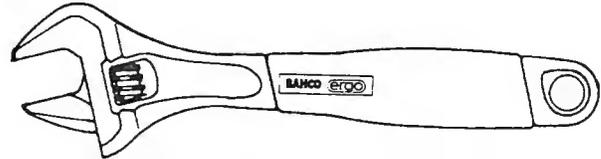
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**A Case Study
in the
Use of Workers' Compensation Data
to Explore
Incidence and Outcome**

Objectives: To calculate the rate of compensable missed worktime injuries in workers in the construction industry in Michigan, 1986 and 1987; to measure the amount of disability in the form of missed worktime produced by these injuries; and, to identify factors which affect the risk of injury or the duration of the resulting disability.

Methods: In cooperation with the Michigan Bureau of Workers' Disability Compensation, we identified the group of Michigan workers who have been paid compensation for an occupational injury or illness that occurred in 1986 or 1987. In Michigan, workers receive compensation if they miss work for more than 7 days following a work-related injury or illness, have specified anatomic or functional losses, or are killed on the job. We estimate that the workers' compensation system covers more than 90% of workers in the Michigan workforce. Occupational illnesses are probably not counted well by the compensation system.

Each compensation payment was converted to a missed worktime estimate by a series of computer programs designed for the project. For each worker injured in 1986, all missed worktime estimates during observation were added together to produce a single cumulative missed worktime estimate. Missed worktime estimates were obtained for more than 98% of the 73,122 1986 cases with some indication of payment in the compensation system. Compensable missed worktime is estimated to account for more than 90% of all missed worktime due to occupational injuries. The cumulative missed worktime estimates in this report include missed worktime beyond the follow-up date of 3/1/90 because all data for an individual were used, including data from "lump sum" claim settlements, or redemptions. The missed worktime equivalent in weeks is defined as the settlement amount divided by that worker's weekly compensation rate.

To obtain injury, industry and occupation characteristics, we matched the compensation records with records in the 1986 and 1987 Michigan Supplementary Data System (SDS) file, a collaborative effort of the Michigan Bureau of Safety and Regulation and the federal Bureau of Labor Statistics. For 1986, 56,206 of the 61,491 SDS cases were matched to the 72,057 cases with missed worktime information (78%). Analysis of a sample of 2,092 unmatched cases indicated that the matched cases are representative of all workers with compensable injuries.

The resulting database contains 11 independent, or predictor, variables and 4 dependent, or outcome, variables. The independent variables are date of injury, gender, age, nature of injury, anatomic area injured, source of injury, type of accident, occupation (census-coded), industry (SIC-coded), establishment employment size and injury cohort (1986 and 1987). The dependent variables, available or potentially available, are 4 variants of missed worktime.

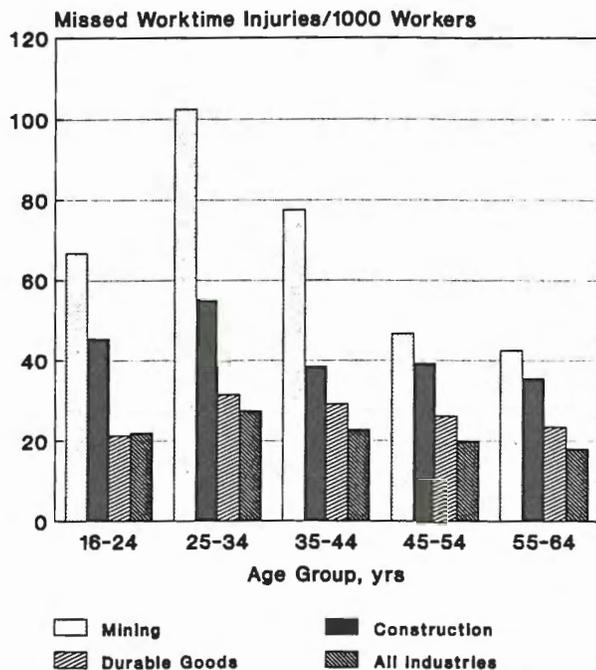
Estimates of the workforce by age were obtained from the 1986 Current Population Survey, a federal survey.

Results: Overall, among male workers, workers in the construction industry (SIC 15-17) constituted 6.0% of the Michigan workforce, had 11.7% of the compensable missed worktime injuries and were responsible for 16.4% of all the missed worktime identified through follow-up, including missed worktime estimated from "lump sum," or redemption, agreements. The odds ratio for compensable injury risk, construction v. all other industries, is 2.1.

Figure 1 shows rates for compensable missed worktime injuries per 1000 workers in selected standard industry groups and for all industries combined. Age- and gender-specific denominator data were obtained by interpolation from estimates of the employed workforce. In 1986, there were only 91 compensable injuries among women construction workers in all 3 SIC construction categories (1.9% of the total). The pattern by age is the same in all industry groups, with the peak risk of injury in the 25-34 year age group and a gradual decline thereafter. The construction industry rates are second highest of those shown, with 4-5% of workers in this industry experiencing a compensable missed worktime injury each year. A comparison of the total employed workforces with the total number of full-time equivalent (FTEs) workers in each of these industry groups suggests that, if estimates of age-specific FTEs were available for 1986, that the age curve for construction injuries would more closely approximate the curve for mining injuries in the first three age groups and would exceed all other industry groups in the two oldest ages.

*Supported, in part, by the University of Michigan Multipurpose Arthritis Center, through an NIAMS grant.

Figure 1
Injury Rate by Industry
Michigan Male Workers Injured in 1986



* Based on employed full-time & part-time workforce. If age-specific FTE data were available, construction rates would be similar to or exceed those for mining.

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Table 1 gives the percentage distribution of the most frequent compensable injuries by occupational group and work location. The construction trades and laborer/helper occupations account for 80% of injuries in the construction industry. Roughly 70% of injuries in construction occupations occur in the construction industry. Back sprains/strains/dislocations, including herniated intervertebral disks, are the most frequent injury in all occupational groups listed, accounting for almost a fifth of all injuries. The rate for this injury among all construction industry workers, 7.58 per 1,000 employed workers, is second only to the transportation industry. Knee sprains/strains, including ligament tears, are the second most common injury, while finger cuts/lacerations/punctures, abdominal herniae and ankle sprains/strains (also includes ligament tears) follow in descending order of frequency. The distributions of injury type differ slightly by worksite, with relatively fewer back and knee injuries in the "other industry" group. The numbers of injuries in the categories listed, representing a 2-year experience of a major industrialized state, are sufficient to support various types of causal modeling aimed at identifying risk factors for these injuries.

Table 1
Missed Worktime Injuries in Construction Occupations by Industry
Michigan: 1986 & 1987 Cases Summed

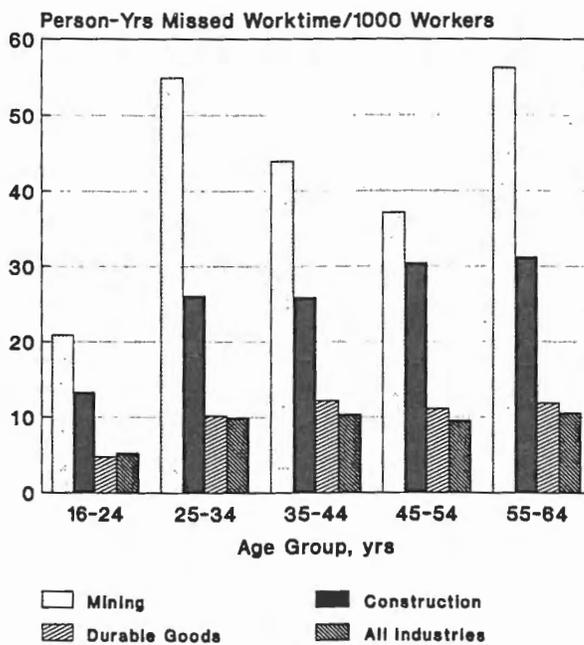
Categories With >100 Cases in Both Years

Body Part	Injury	Work Location			All	N
		Construction Trades	Laborers Helpers	Construction Occupations in Other Industries		
		(column pct)				
Finger	Cut	5.3%	3.8%	2.7%	4.2%	461
Finger	Fracture	2.0%	3.6%	1.4%	2.2%	236
Wrist	Fracture	1.9%	2.0%	0.8%	1.6%	176
Hand	Cut	2.4%	1.7%	0.9%	1.8%	198
Hand	Fracture	1.0%	2.1%	0.7%	1.1%	122
Shoulder	Sprain/Disloc	2.5%	2.9%	1.3%	2.2%	245
Back	Sprain/Disloc	19.0%	19.1%	13.9%	17.5%	1908
Abdomen	Hernia	4.7%	3.3%	3.0%	3.9%	425
Knee	Sprain	7.6%	5.6%	3.6%	6.0%	652
Ankle	Sprain	3.3%	3.6%	2.5%	3.1%	340
Ankle	Fracture	2.3%	2.2%	1.1%	1.9%	208
Foot	Fracture	2.9%	3.1%	1.7%	2.6%	278
Toe	Fracture	1.3%	2.1%	1.1%	1.4%	153
sub-total		56.4%	55.0%	34.8%	49.6%	5402
Other Injuries		43.6%	45.0%	65.2%	50.4%	5487
		100.0%	100.0%	100.0%	100.0%	
All Cases	N (col sum)	5388	2231	3270		10889

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Through follow-up to 3/1/90, the 4,667 male construction workers injured in 1986 had accumulated 2,596 person-years of missed worktime, including the missed worktime attributed to "lump sum" settlements, with a median missed worktime of 6.2 weeks and an average of 28.9 weeks. These missed worktime figures are minimum estimates, because they do not reflect the 14.7% underestimate of missed worktime by our algorithms or the 53.3% underestimate represented by insurance company reserves set aside for future payments to the entire 1986 injury cohort for the period roughly beyond our follow-up date. The much longer average missed worktime is due to the 15% of workers with the longest missed worktimes. For comparison, the median and average for all injuries were 4.8 and 20.7 weeks, respectively.

Figure 2
Missed Worktime by Industry Through
3/1/90 for Michigan Male Workers*
Injured in 1986



* Based on employed full-time & part-time workforce. If age-specific FTE data were available, construction rates would be similar to or exceed those for mining.

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Conclusions:

1. Construction industry workers are more than twice as likely to have a compensable work injury as workers in other industries.
2. Back and knee sprains/strains/dislocations, including herniated intervertebral disks and torn ligaments, are the most frequent injuries.
3. Injured construction industry workers have longer disabilities, as measured by missed worktimes, than workers in other industries. It is not known whether the cause is more serious injuries initially or whether the nature of the work performed in the construction industry requires that workers be more fully recovered before returning to work.
4. Workers' compensation data, carefully interpreted, can serve as a valuable source of information on occupational injury and disability in the construction industry.

Figure 2 gives the missed worktime rates per 1,000 employed workers by age for selected and all industries. The Figure shows that construction industry workers have the 2nd highest missed worktimes, in the overall range of 20-25 person-years per 1000 employed workers, and the missed worktime experience is worst for oldest workers. This places them second only to the mining industry. As noted, with respect to Figure 1, if adjustments for full-time equivalent workers by age and industry were available, then the construction industry rates would more nearly approximate those in the mining industry. It is unclear whether the high missed worktime rates are due to more serious injuries in construction industry workers or to greater difficulty in returning to work while there is residual disability, to a combination of these, or to other factors.

Notes

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This document was made possible by grant numbers U60/CCU306169 and U02/CCU308771 from the National Institute for Occupational Safety and Health. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of NIOSH.

APPENDIX 2

Press Release

PRESS RELEASE

National Conference on Ergonomics, Safety, and Health in Construction *Setting the Agenda and Creating a Coalition*

July 21, 1993

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(c/o Director's Room)
(after hours: 202-328-9536)
202-962-8493 (after July 22)

FOR IMMEDIATE RELEASE:

NATIONAL CONFERENCE SETS TEN GOALS TO IMPROVE CONSTRUCTION SAFETY AND HEALTH

WASHINGTON -- A national labor-management organization, vastly improved data sets, and new approaches to regulation are among the recommendations to improve safety and health produced by the first *National Conference on Ergonomics, Safety, and Health in Construction* at its last plenary session Wednesday.

The conference, an effort to reduce the appalling rate of work-related injuries and illnesses among construction workers in the United States, heard experts from a wide range of disciplines -- public health, engineering, government, scientific research, and economics -- in the United States, Europe, Canada, and Australia. Some 2,100 construction workers in the United States die of work-related injuries -- eight per workday -- at a rate four times the rates in Japan, the Netherlands, Sweden, and Ontario, Canada.

Prof. John Dunlop of Harvard University, conference rapporteur, delivered ten recommendations to most of the 750 participants at the concluding plenary session at the Omni Shoreham Hotel Wednesday. His recommendations were based on three days of presentations and workshop discussions involving more than 100 speakers.



Dunlop, chair of the U.S. Commission for the Future of Worker-Management Relations, said, first, there is an "urgent" need to establish a national organization to further safety and health. It should comprise unions and contractors engaged in collective bargaining.

The economist said the organization should foster discussion and seek agreement on safety and health standards and draw on the best scientific and medical data (governmental and private), and recommend standards to OSHA -- instead of the other way around. Unions and some contractors are a good starting point for the national organization, the rapporteur said, but other management organizations and labor need to be included down the road.

In addition, Dunlop listed the following:

2. Site-specific safety and health programs are clearly needed. All projects above a given size need safety committees and those committees should have specialized training and be involved in project planning -- including a pre-job planning meeting.
3. Vastly improved -- detailed -- data sets are needed. This is above and beyond improvement in U.S. Bureau of Labor Statistics data that are expected by early 1994.
4. New approaches to regulation are needed, particularly negotiated rulemaking -- involving all interested parties -- before the issuance of most regulation.
5. Efforts, such as those by Bechtel to change workers' compensation -- at least project by project, for example in Massachusetts -- are to be applauded and should be encouraged. In addition, the national safety and health organization should help to develop processes at state levels to modify workers' compensation procedures.
6. The inability to clearly differentiate work-related from other health problems necessitates combining medical coverage under workers' compensation with general health insurance.

7. **Joint union-management health and welfare programs mandated by Taft-Hartley should be used to improve worker health.**
8. **Joint labor-management training programs are essential for improved safety and health in construction.**
9. **International linkages -- such as those established for this conference with union-management organizations in Germany, the Netherlands, Sweden, and Ontario, Canada -- should be fostered. This effort should recognize that some institutions are more transferable than others.**
10. **More research is needed, including research on the economics of safety and health practices.**

The conference was sponsored -- among others -- by the U.S. Department of Energy, the U.S. Occupational Safety and Health Administration (OSHA), the National Institute for Occupational Safety and Health (NIOSH, part of CDC), the National Constructors Association, and the Center to Protect Workers' Rights, representing the nation's 15 building and construction trades unions.

Two special simultaneous day-long sessions -- on workers' compensation and on research needs -- were set for Thursday, July 22, at the Omni Shoreham Hotel.

A conference report based on the recommendations will be presented to industry leaders, Congress, and federal agencies.

APPENDIX 3

LU Survey Questions on Ergonomics - IBEW National
Leadership Survey, Preliminary Results

48. List the top 5 ergonomic hazards in your trade(s): (e.g., use of a knee-kicker for carpet layers, overhead work, pulling cable)

<u>Hazard</u>	<u>Trade</u>
1) _____	_____
2) _____	_____
3) _____	_____
4) _____	_____
5) _____	_____

49. List the top 5 ergonomic injuries in your trade(s): (e.g. shoulder, back, hand, or wrist injuries)

<u>Injury</u>	<u>Trade</u>
1) _____	_____
2) _____	_____
3) _____	_____
4) _____	_____
5) _____	_____

50. List examples of any ergonomic improvements which have been or could be made: (e.g., new safer tools, better work practices, use of lifting devices)

- 1) _____
- 2) _____
- 3) _____
- 4) _____
- 5) _____

assistance where needed;

- *Identify safety issues in industry, train to meet needs;
- *Committee attends most seminars on a State/Federal level;
- *Program set up on individual basis according to need through JATC committee;
- *Advise members/contractors of unsafe conditions review accidents on job;
- *Provide information on safety and health issues;
- *Research lost time accidents, private safety training for new members, maintain safety records;
- *Meet on an "as needed" basis.

Section VII: Exposure Information

The following is an overall averaged percentage of total responses.

The top ten potentially hazardous chemicals or potentially hazardous situations encountered by the local memberships are:

- 40% Asbestos
- 26% Electrical shock/electrocution
- 20% PCB
- 18% Falls
- 10% Working at high elevations
- 8% Paint fumes, carbon monoxide, chlorine
- 8% Unsafe ladders
- 6% Lead
- 6% No railings on balconies, open trenches/holes
- 5% Dealing with traffic

Some of the most common tasks which result in the highest number of injuries to the locals' members were:

- 31% Improper moving/lifting, which results in back injuries/strains
- 20% Slips/trips/falls
- 14% Climbing ladders and scaffolds
- 10% Working around/with energized equipment
- 9% Eye injuries
- 8% Cuts/lacerations
- 6% Carpal tunnel syndrome
- 4% Electric shock, flashes, burns
- 4% Knee injuries
- 3% Carelessness

The top ergonomic hazards for electricians are:

- Pulling cable
- Overhead work
- Heavy lifting
- Ladders/scaffolds
- Energized circuits

The top 5 ergonomic hazards for linemen are:

- Climbing**
- Lifting heavy loads**
- Electric shock/electrocution**
- Pulling cable**
- Falls from scaffolds/trees/ladders**

The top ergonomic hazards for wiremen are:

- Energized circuits**
- Lifting/working overhead**
- Pulling blocks/hoists**
- Falls from scaffolds/ladders**
- Repetitive motions**

The top ergonomic hazards for construction workers are:

- Heavy lifting**
- Pulling blocks/hoists**
- Falls from scaffolds/ladders**
- Repetitive motions**
- Weather conditions**

In response to the top ergonomic injuries in their trade the following was revealed:

- *Linemen responded back problems, carpal tunnel/hand /wrist injuries, knees, cuts, eye, tendinitis, shoulder, legs/feet/ankle, hips and burns**
- *Treerimmers responded back problems, hand/wrist/carpal tunnel, knees, shoulder injuries**
- *Electrical workers experienced back injuries, hand/wrist/carpal tunnel, eye, knees, shoulders, head and neck, legs/feet/ankle, and burns**
- *Construction workers responded neck, hand/wrist/carpal/tunnel and shoulders.**

Some ergonomic improvements which have been or could be made are as follows:

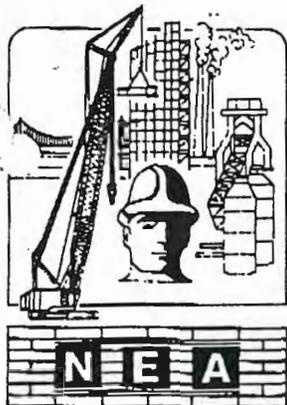
- Better work practices**
- Lifting devices**
- Pneumatic tools with instructions of use**
- A better selection of ergonomically designed and safer tools**
- Safety training and education**
- Protective equipment/clothing**
- Keeping a clean work area**

APPENDIX 4

NEA Survey and Summary of Results

SAMPLE

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EXECUTIVE VICE PRESIDENT
Noel C. Borck

May 26, 1993

Mr. William Treharne
Broad, Vogt & Conant, Inc.
195 Campbell Street
River Rouge, Michigan 48218

Dear Mr. Treharne:

The National Building and Construction Trades Department, through its non-profit research arm the Center to Protect Workers' Rights (CPWR), has implemented an ergonomic study of musculoskeletal problems in the construction industry. Some studies indicate that injuries from these problems, including back and shoulder industries account for almost two thirds of the total workers' compensation costs in our industry.

To assist the CPWR in conducting a survey for their upcoming National Conference on Ergonomics and Workers' Comp to be held in Washington, D.C. July 18-25th, we have enclosed a short questionnaire. We hope that you will cooperate in this effort by completing the questionnaire and returning it to the NEA National Office by June 18, 1993. The purpose of the questionnaire is to gather information on the scope of musculoskeletal injuries, specific hazards that may cause these injuries and possible practical solutions or training that may be implemented to prevent these injuries.

This is an important study that requires "real life" input from contractors. Without that input, theoretical solutions which do not take into account practicality and cost effectiveness may be proposed by OSHA, the federal government and other regulatory agencies.

If you have any questions, please contact Eric Waterman at the NEA office or Pete Stafford at the CPWR at 202-962-8490.

Very truly yours,

Wayne Rice

William Treharne

Co-Chairman NEA Safety and Health Committee

/jk
cc: N.C. Borck

1501 LEE HIGHWAY/SUITE 202/ARLINGTON, VIRGINIA 22209
(703) 524-3336/FAX (703) 524-3364

NEA CONTRACTOR QUESTIONNAIRE ON ERGONOMICS

1) How many employees do you normally have?

1-10 _____
10-25 _____
25-50 _____
50-100 _____
> 100 _____

2) Describe the type of work that you perform:

	% of work
Commercial	_____
Residential	_____
Industrial	_____
Heavy/Highway	_____
Renovation	_____
Demolition	_____

3) Please list the types of tasks performed by your employees that account for the largest number of injuries.

a) What tasks account for the largest number of sprains and strains?

4) What are the most common sprain and strain injuries your employees incur on the job?

Back _____
Wrist _____
Arm/shoulder _____
Knee _____
Other (describe) _____

5) What is the total cost your company pays out each year in workers' compensation premiums and payments?

6) How are those costs divided up?

	% of injuries	% of costs
Back injuries	_____	_____
Wrist injuries	_____	_____
Arm/shoulder injuries	_____	_____
Knee injuries	_____	_____

7) Does your company have a program to control these injuries?

Yes _____ No _____

If yes, please answer these questions about each of the following elements: training, job analyses and modifications and new equipment design.

a) Has your company instituted a training program to prevent strain and sprain injuries (e.g., proper lifting, etc.)?

Yes _____ No _____

If yes, please describe the program:

Do you have any evidence that the training program has helped reduce injury rates or prevented injuries?

Yes _____ No _____

If yes, please explain:

b) Has your company done any job analyses to look at how jobs could be modified to reduce the risk of sprains and strains?

Yes _____ No _____

If yes, what types of analyses were used?

What jobs have been identified as hazardous?

What modifications have been made?

Do you have any evidence that these modification have helped reduce injury rates or prevented injuries?

c) Does your company take ergonomic design into consideration when buying new tools and equipment?

Yes _____ No _____

If yes, is your company willing to spend more to buy equipment which could reduce the risk of injuries (e.g., chipping hammers with reduced vibration)?

What tools or equipment has your company purchased that are designed to reduce the risk of injuries?

Do you have any evidence that these new tools have helped reduce injury rates or prevented injuries?

8) Does the company provide protective equipment to prevent sprain and strain injuries (e.g., back belts, wrist splints)?

Yes _____ No _____

If yes, what types of equipment are provided?

What evidence (e.g., lowered injury rates) do you have that they have helped reduce injury rates?

9) Does the company have a program to help injured workers?

Yes _____ No _____

a) Is there an attempt to provide light duty jobs to get injured workers back to work sooner?

Yes _____ No _____

b) Do you or your compensation carrier pay for retraining (back to school) and rehabilitation services for injured workers?

Yes _____ No _____

10) In your opinion, what is the most effective way to prevent ergonomic injuries in the construction industry?

**NEA CONTRACTOR QUESTIONNAIRE ON ERGONOMICS
SURVEY RESULTS**

The following are the results taken from the 22 local contractors who responded to the ergonomic questionnaire.

13 local contractors have more than 100 employees. 5 have 50-100, 3 with 25-50 and 1 with 1-10 employees.

The type of work done is tabulated as follows:

<u>Commercial</u>		<u>Residential</u>		<u>Industrial</u>	
10%	3 responses	2%	1 response	30%	2 responses
24%	1 response	14.8%	1 response	40%	1 response
24.8%	1 response			43%	1 response
30%	3 responses	<u>Demolition</u>		50%	1 response
40%	1 response	10%	1 response	60.4%	1 response
70%	2 responses			70%	2 responses
100%	1 response			90%	3 responses
				100%	5 responses
<u>Heavy/Highway</u>		<u>Renovation</u>			
5%	1 response	6%	1 response		
10%	1 response	20%	1 response		
90%	1 response	60%	1 response		
100%	1 response				
"x"	2 responses				

Lifting was the most listed task performed by employees that accounted for the largest number of injuries, with 9 responses. Climbing, material handling, and welding/cutting each had 4 responses; moving had 3 responses; pulling, slips/trips/falls and back/limb injury 2 responses each; and jack hammer, unloading, iron workers, steel erection, moving items by hand, back stepping off cranes, breaking bolts, hammer wrenches, minor eye injuries and grinding account for other responses.

Again, lifting was the response that accounts for the largest number of sprains and strains, with moving items by hand(4 responses), material handling(3 responses), and slips/falls and pulling(2 responses)being among the top responses. Other responses include unloading, walking, bumping into objects, assembly, binding and climbing on/off equipment(trucks, trailers, cranes).

Back injuries was the most common sprain/strain injury incurred by employees on the job with 20 responses. Knee injuries had 10 responses; other injuries include arm/shoulder(6 responses), wrist(2 responses), ankles(2 responses), hand cuts, and abdominal-hemia.

Total cost that companies pay out in workers' compensation premiums and payments each year range from \$1,000 to 1 million dollars.

These costs are divided up according to % of injuries and % of costs. One response based their costs on gross payroll not injuries.

20 local contractors responded they do have a program to control these injuries and 17 responded they have instituted a training program to prevent strain and sprain injuries. Some of the training programs include use of video and safety review meetings, instruction on proper lifting techniques at tool box meetings and with new hire indoctrination, demos at weekly safety meetings, current up to date on prevention of accidents.

8 local contractors responded they have evidence that the training program has helped reduce injury rates and prevented injuries. Others who responded feel there is no hard evidence and a few are still evaluating the program.

9 companies have done job analyses to look at how jobs could be modified to reduce risk of sprains and strains. The types of analyses used involved individually analyzing each job to assess risk and then incorporate methods of prevention, field observations, general review by trained safety professionals, look at tasks and modify work to workers, and common sense with discussion and refinement or change.

Jobs identified as being hazardous are climbing and walking structural steel, climbing ladders and heavy/awkward lifting. Some modifications include more training, job rotation, engineering changes, buddy system for lifting, focus on maintaining housekeeping, use of static lines, safety belts and lanyards on structural steel and get help if lifting over 25lbs while wearing a back belt or use mechanical help when lifting over 75lbs. It appears that injuries are being reduced with a reduced incidence rate.

12 contractors responded that their company takes ergonomic design into consideration when buying new tools and equipment, and are willing to pay more for equipment that could reduce the risk of injuries. Some tools and equipment already purchased include grinders with proper guards installed, anti-two blocking for crane, equipment for lifting and handling heavy loads, jack hammers with reduced vibration, hand trucks, roust-a-bouts, body harnesses, leather sleeves, lo max suits, gas masks, gas monitors, safety belts, safety glasses, and crane forklifts are used more. With the use of these tools and equipment it appears that injuries have been reduced. Some contractors still don't have enough evidence in regards to tool and equipment reducing injuries, but believe it has improved.

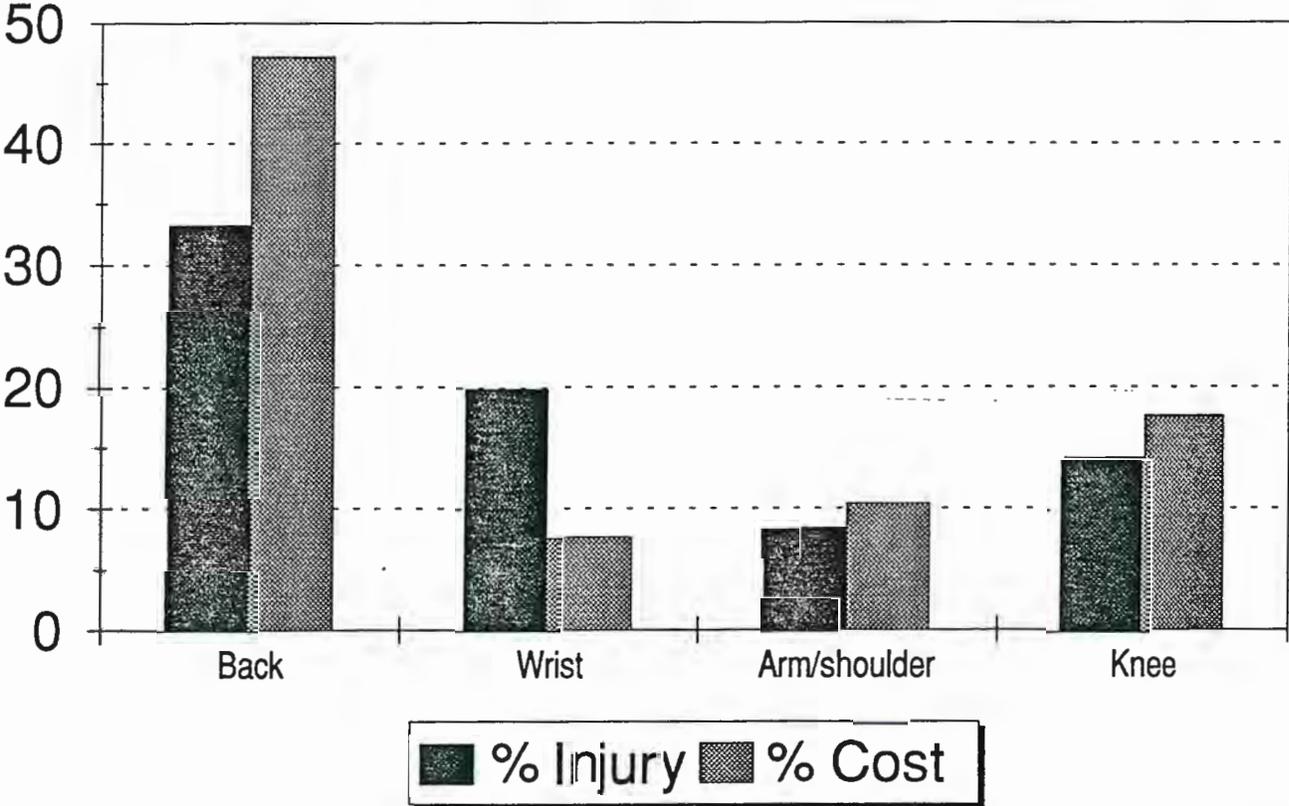
9 companies provide protective equipment to prevent sprain and strain injuries. Majority of them provide back belts. The evidence that protective equipment has helped reduce injury rate is currently being evaluated by a few companies. Some companies have 90% reduction on costs with no operable claims in 18 months, others have seen lowered injury rates as well as fewer accidents.

19 companies have a program to help injured workers with an attempt to provide light duty jobs to get injured workers back to work sooner. The company or the compensation carrier pay for retraining and rehabilitation services for injured workers.

In preventing ergonomic injuries training was the number one response. In light with that, determine what most ergonomic injuries are and do something to control them; must stay in good physical shape—more important with aging; good training on use of each tool and operation and employees need to take personal responsibility for own safety and following safety policies.

NEA Injuries

(An averaged % of total responses)



NEA CONTRACTOR QUESTIONNAIRE ON ERGONOMICS

1) How many employees do you normally have?

1-10	<u>(1)</u>
10-50	<u>(0)</u>
25-50	<u>(3)</u>
50-100	<u>(5)</u>
>100	<u>(13)</u>

2) Describe the type of work that you perform:
% of work

Commercial	<u>100%(1); 70%(2); 40%(1); 30%(2); 24%(2); 10%(3); "x"(1)</u>
Residential	<u>14.8%(1); 2%(1)</u>
Industrial	<u>100%(5); 90%(3); 70(2); 60.4%(1); 50%(1); 43%(1); 40%(1); 30%(2); "x"(2)</u>
Heavy/Highway	<u>100%(1); 90%(1); 10%(1); 5%(1); "x"(2)</u>
Renovation	<u>60%(1); 20%(1); 6%(1)</u>
Demolition	<u>10%(1)</u>

3) Please list the types of tasks performed by your employees that account for the largest number of injuries.

Jack hammer(1)	Steel erection(1)
Lifting(9)	Moving items by hand(1)
Pulling(2)	Back stepping off cranes(1)
Moving(3)	Struck by moving object(1)
Unloading(1)	Breaking bolts(1)
Back & limb injury(2)	Hammer wrenches(1)
Climbing(4)	Falls/slips/trips(2)
Material handling(4)	Minor eye injuries(1)
Welding/cutting(4)	Grinding(1)
Iron workers(1)	NO ANSWER(3)

a) What tasks account for the largest number of sprains and strains?

Lifting(12)	Moving items by hand(4)
Pulling(2)	Material handling(3)
Unloading(1)	Assembly(1)
Walking(1)	Binding(1)
Bumping into objects(1)	Climbing on/off equipment(1)
Slips/falls(2)	NO ANSWER(2)

4) What are the most common sprain and strain injuries your employees incur on the job?

Back	<u>19</u>
Wrist	<u>1</u>
Arm/shoulder	<u>5</u>
Knee	<u>10</u>
Other(describe)	<u>ankles(2); handcuts(1); abdominal-hernia(1)</u>

5) What is the total cost your company pays out each year i workers' compensation premiums and payments?

\$600,000-1 million	\$146,869.50 payments/\$231,808 premiums
\$220,000	\$3,000 payments/\$135,000 premiums
\$1,000,000	\$331,041.40
\$1,000	'91, '92, '93 to date \$300,000
\$500,000(2)	\$95,000
\$1,600,000 in 1992	\$750,000/yr+
\$2500,000	\$300,000
\$241,035 in 1992	NO ANSWER(4)
\$281,000	NOT AVAILABLE(1)

6) How are those cost divided up? SEE ATTACHED GRAPH

7) Does your company have a program to control these injuries?
Yes 20 No 1 Not a specific "back problem"

If yes, please answer these questions about each of the following elements: training, job analyses and modifications and new equipment design.

a) Has your company instituted a training program to prevent strain and sprain injuries (e.g. proper lifting, etc.)?

Yes 17 No 4 SKIP (1)

If yes, please describe the program:

- Use of video and safety review meetings(3)
- Instruction on proper lifting during tool box meetings(5)
- New hire indoctrination; lifting techniques training(2)
- Weekly safety meetings—current data on prevention of accidents/injuries; work towards safe work environment
- Demos at weekly safety meetings
- Monthly safety meetings

Do you have any evidence that the training program has helped reduce injury rates or prevented injuries?

Yes 8 No 6 No answer 3 SKIP 2 No answer 1
Currently Evaluating

If yes, please explain:

- Declining incidence rate, acceptance of new safety procedures in field, more discussion from field personnel
- People think more
- No real evidence, carpal cases are being reduced & number/cost of back injuries are down
- Fall incidence have continued to decline over 10yrs
- Have realized 90% reduction in costs associated with back strain
- Meetings help reduce number of accidents each year
- Reduction in claims
- More employee safety awareness of safe procedures; decrease in incident rate
- Observed fewer injuries as employees are made more aware of "causes" & have become more preventive conscious

b) Has your company done any job analyses to look at how jobs could be modified to reduce the risk of sprains and strains?

Yes 9 No 11 Yes/no 1 NO ANSWER 1

If YES, what types of analyses were used?

SKIP 11 NO ANSWER 1

- Each job must be analyzed individually to assess risk and then incorporate methods of prevention
- Field observations(2)
- General review by trained safety professionals
- Job safety analysis
- Look at tasks and modify work to workers
- Evaluation of workers comp cases with insurance carrier to determine most common loss types
- Common sense; discussion and refinement or change

What jobs have been identified as hazardous?

- Climbing & walking structural steel
- Climbing ladders
- Heavy/awkward lifting

What modifications have been made?

- More training(2)
- Over 25lbs get help, wear a back belt; over 75lbs use mechanical help
- Job rotation
- Engineering changes
- Buddy system for lifting
- Focus on maintaining housekeeping
- More lift equipment
- Use of static lines
- Safety belts and lanyards on structural steel

Do you have any evidence that these modifications have helped reduce injury rates or prevented injuries?

- Yes
- Reduced incidence rate
- Yes, but costly cases involve those with pre existing conditions which increases likelihood that a routine job function may lead to injury
- No hard evidence
- It appears injuries are being reduced

c) Does your company take ergonomic design into consideration when buying new tools and equipment?

Yes 12 No 8 No answer Being studied

If yes, is your company willing to spend more to buy equipment which could reduce the risk of injuries (e.g., chipping hammers with reduced vibration)?

Yes(11) No answer(4) SKIP(4) Definitely Possibly
Especially grinders with guards

What tools or equipment has your company purchased that are designed to reduce the risk of injuries?

- Grinders with proper guards installed
- Anti-two blocking for crane
- Equipment for lifting & handling heavy loads
- Jack hammers with reduced vibration(2)
- Hand trucks
- Utilizing crane forklifts more
- Safety eyewear, built in side shields
- Roust-a-bouts
- Body harnesses
- Leather sleeves, lo max suits, small vending, gas masks machines, gas monitors, safety belts, safety glasses

Do you have any evidence that these new tools have helped reduce injury rates or prevented injuries?

- It appears that injuries have been reduced(2)
 - No evidence, we believe it has improved(2)
- Yes 5 No 4 SKIP 3 No answer 5 None 1

8) does the company provide protective equipment to prevent sprain and strain injuries(e.g., back belts, wrist splints)?

Yes 9 No 13

If yes, what types of equipment are provided?

SKIP(12) Wrist splints(computer operators)(2)
Back belts(10) Padded absorbent work gloves

What evidence (e.g., lowered injury rates) do you have that they have helped reduce injury rates?

SKIP(10) No answer(4) None(2)

- Currently evaluating(2)
- 90% reduction on costs, no operable claims in 18 months
- Lowered injury rates
- No hard evidence
- Fewer accidents

9) Does the company have a program to help injured workers?

Yes 19 No 3

a) Is there an attempt to provide light duty jobs to get injured workers back to work sooner?

Yes 21 No 1

b) Do you or your compensation carrier pay for retraining (back to school) and rehabilitation services for injured workers?

Yes 15 No 7

10) In your opinions, what is the most effective way to prevent ergonomic injuries in the construction industry?

- Determine what most ergonomic injuries are and do something to control them
- Good instruction: training on use of each tool and operation; keep safety guard in place
- Must stay in good physical shape, more important with aging
- Training; mandatory use of back belts; employee taking personal responsibility for own safety and following safety policies
- Good training on work place hazards
- Employee training and honesty
- Training key factor(8)
- Review basic lift techniques(2)
- Worker awareness of safe practices

APPENDIX 5

Ergonomics and Construction Review Article and Letter of
Acceptance from AIHA Journal

RECEIVED SEP 14 1993

Editor in Chief
Howard J. Cohen, Ph.D., CIH

September 10, 1993

Scott Schneider, CIH
Center to Protect Workers Rights
111 Massachusetts Ave.
Washington, DC 20001

Re: Manuscript #131 - Reviewion 3

Dear Mr. Schneider:

This is to acknowledge that your manuscript has been accepted for publication by the AIHA Journal for Section II. Your entire file has been sent to the national office of AIHA. You will receive galley proofs to review from the national office, prior to the publication of your manuscript. Please send camera-ready figures to E. Simon at the address below and for all future correspondence, please contact:

AIHA Journal
2700 Prosperity Avenue
Suite 250
Fairfax, VA 22031
703-849-8888; FAX 703-207-3561

Also enclosed is a computer disk of an older version of the manuscript which was still in your file.

Congratulations on having your manuscript accepted for publication, and thank you for choosing the AIHA Journal to publish your work.

Sincerely,

Howard J. Cohen
Editor in Chief

HJC/jm

**ERGONOMICS AND CONSTRUCTION:
A REVIEW OF POTENTIAL HAZARDS IN NEW CONSTRUCTION**

Scott Schneider*, CIH, and Pam Susie*, IH

Occupational Health Foundation

* Current address: Center to Protect Workers' Rights
111 Massachusetts Avenue, NW
Washington, DC 20001

ABSTRACT

Ergonomics is a growing field within occupational safety and health. Ergonomic hazards are those where the design of the work or workplace causes injury, e.g., musculoskeletal problems. Injury rates attributable to ergonomic hazards are increasing rapidly, accounting, for the first time, the majority of "occupational diseases" in the 1989 annual survey by the U.S. Bureau of Labor Statistics⁽¹⁾. While interest and attention has been growing, most of the focus has been on industrial and office workers. Little research has been done in the U.S. on ergonomic problems for construction workers. This paper is a review of potential ergonomic hazards in construction work. It summarizes the findings from published literature reports as well as findings from a fifteen month-long investigation of health hazards on a new construction site in suburban Washington, D.C.. The review is structured to follow the sequence of events in the construction process. The review also includes ergonomic solutions where they have been developed. This review only deals with the hazards of new construction. Renovation and demolition of existing structures and highway work, the segments of the work which are growing, are not discussed here. However, many of the same problems and principles apply to other sectors of construction.

INTRODUCTION

Constructing a new building is, by its very nature, a problem in ergonomics. Installing floors and ceilings requires work at floor and ceiling height, which by definition is ergonomically hazardous since ceilings have to be above shoulder level and floors below knee height. Building materials are necessarily heavy and present manual materials handling problems. Little research has been done in the U.S. to identify the specific risks for each trade or each phase of the building process. Swedish researchers at the Construction Industry's Organization for Working Environment, Occupational Safety and Health (Bygghälsan) have done a considerable amount of work in this area, but much has been published internally and has not shown up in refereed journals.

Methods

A team of industrial hygienists followed the construction of a four-story office building for the fifteen month duration of the project. Walk throughs of the site were made about twice a month. Air samples were taken for chemical hazards and noise measurements were made. Those results will appear in subsequent papers. During the walk throughs, jobs which appeared ergonomically stressful were videotaped and workers were interviewed about the ergonomic risks of their jobs. A review of the published literature was conducted. Contacts were also made with

research organizations doing similar research. While the results presented are mostly qualitative, based on our observations, most field studies looking at risk factors for back disorders, one of the major problems in construction, to date have been qualitative⁽²⁾. Descriptive studies are a necessary precursor to more quantitative work. That is, hazard identification must precede exposure measurement.

This paper presents a review of the observed ergonomic problems in construction. The review is structured to follow the sequence of events in the construction of a new building. Tables are included in an appendix which summarize the ergonomic risk factors for each phase of the work. The review will also, simultaneously, refer to ergonomic solutions that exist, where they have been developed or devised. A table summarizing these solutions can be found at end of the review. Many of the identified problems are associated with crafts and tasks are not unique to "new construction" and could be found in, for example, renovation work as well.

EXCAVATION AND FOUNDATION WORK

Excavation and site preparation involves movement of earth to achieve a desired grade. This process involves the use of heavy equipment to dig ditches for footings and foundations, build up grade in low areas and backfill areas where preliminary work has been completed. The resulting terrain is a rugged and uneven area of hills and ditches with the occasional level

surface. Generally a crew of at least two, usually carpenters, are designated to assist heavy equipment operators in adjusting grade. This is typically accomplished by use of a transit and a story pole or folding rule. The transit operator levels the instrument to a reference elevation point (bench mark) , which remains fixed for the duration of the job. Once the reference elevation is established, the site layout crew is able to establish the amount of earth that must be removed or filled in to achieve grade specifications. While the transit operator generally remains in a stationary position on level ground, the individual holding the grade rule or pole must climb in and out of ditches and over uneven terrain. This work may place considerable stress on the lower body through awkward postures and continuous walking on uneven surfaces.

Work has to begin with the excavation of the site, which necessarily involves heavy earth moving equipment. The ergonomic hazards of this equipment are well known⁽³⁾. They are the hazards of whole body vibration and poor seat design. In addition, operators often have to twist and turn to while operating their vehicle in reverse. A NIOSH study of heavy equipment operators found several musculoskeletal disorders associated with exposure to vibration⁽⁴⁾. Although the overall incidence was not increased significantly, this may have been due to selection factors, i.e., workers dropping out due to medical problems.

Manufacturers have redesigned seats and cabs over the past two decades to isolate the operator from equipment vibration with some success. Older equipment is still in use, however, which is not as well designed ergonomically as the newer models. Retrofitting old equipment is clearly feasible. Redesign and adaptation of operator's seats has enabled even disabled workers to return to work successfully in a pilot program in Sweden⁽⁵⁾. Adjustable seats providing more neck, arm and lumbar support were tested and found to essentially eliminate discomfort⁽⁶⁾.

Foundation work involves forming concrete footings and retaining walls for the building. Trenches are dug using heavy equipment or by hand shovelling, and concrete forms are built. Concrete is poured into forms and allowed to set, after which the forms are removed. This work involves difficult postures at times because work is often done in trenches. Motorized hand tampers are used to compact soil before a slab is poured. These tampers are hand held and produce hand-arm vibration as well as gasoline vapors. Monitoring of the vibration levels produced by this equipment is planned for future projects.

Shoveling can be very strenuous on the lower back⁽⁷⁾. Ergonomically designed shovels with a longer, bent handle are available in Sweden. This design has been shown to lessen the risk of back injury among workers doing hand shovelling⁽⁷⁻¹⁰⁾.

MASONRY

Early on in this project, masonry walls were built at ground level. This process involves a lot of hand carrying and lifting of masonry blocks. While this project did not involve a significant amount of brick work, brick laying has been shown to present important ergonomic hazards to workers. Bricklayers average about 1,000 bricks a day that they must lift, resulting in a total of 2,300- 4000 kg (about 5,000- 8,800 lbs) of lifting per day and 1,000 trunk twist flexions⁽¹¹⁾. One consequence is that about 87% of bricklayers have low back problems over their lifetime (as compared with 46% for painters)⁽¹¹⁾. Bricklaying has been shown to cause severe muscle fatigue⁽¹¹⁾. The lumbar load has been shown to be very high when laying bricks, particularly when laying bricks on a low wall (10 cm or 4 in high)⁽¹²⁾. Constant stooping to get materials and place them on the wall with precision places great strain on the back, primarily because of the changing height of the work. One study showed that bricklayers spend up to 75% of their time in a bent over posture, primarily when stooping to lay a course of bricks on a low wall and stooping to get bricks and mortar⁽¹³⁾. The authors recommended adjustable scaffolds to keep the working height between 60 and 90 cm (2-3 ft). Brick supply stacks should also be kept to at least 50 cm high (20 in)⁽¹²⁾. One result of such a system has been an increase in productivity of up to 100%.

Research has demonstrated a significant reduction in lower back stress by having an adjustable height work platform on the scaffold, use of motorized work platforms which could be lowered or raised in small increments, and pumping of mortar onto the platform and to the point of application⁽¹⁴⁾. Sweden also set new standards for masonry blocks and bricks, effective in 1987, limiting bricks to be handled by 1 hand to a maximum of 3 kg (7 lbs)⁽¹⁵⁾. Heavier blocks must be handled two-handed and, if they weigh between 12 and 20 kg (26-44 lb), only between knee and shoulder level. Blocks over 20 kg (44 lb) must be handled by hoists or other lifting equipment. In addition, in Germany, masonry blocks have been redesigned to include hand holds to make them easier to lift⁽¹⁶⁾. Materials handling equipment is also used extensively for masonry work in Germany.

On the job we studied, grout was also poured into the masonry wall on the ground floor to stabilize it. This required hand carrying buckets of grout about 1.2-1.8 M (4-6 feet), hoisting them onto a scaffold and pouring them into the wall at about knee height. Bucket weight ranged from about 20-34 kg (45-75 pounds). This presented a risk of back and shoulder injury⁽¹⁷⁾. Bucket design was poor with uncomfortable handles placing ergonomic stress on the hands. Blocks may also be filled with concrete to give strength to load bearing areas such as corners and door and window headers.

Elevator piston shafts were also sunk into the ground at this stage, which we observed presented workers with high noise levels and heavy equipment vibration problems.

FORMWORK

Formwork is the general term used to describe the variety of molding systems used in concrete construction. Today, the bulk of commercial carpenters are engaged in concrete construction work. The most common system used for concrete construction are field constructed plywood or metal forms. Other systems used for concrete construction include slip forms, pan construction, tilt-up pre-cast systems and post-tensioned systems. The ergonomic hazards associated with concrete form work is dependent on the system that is being used.

Concrete structures that are commonly formed include footings, walls, columns, and beams. All buildings contain some degree of formwork, from those buildings that contain at the minimum a formed floating slab to those buildings that are both structurally and architecturally concrete. The new construction project we observed contained relatively little formwork, with footings, slabs and non-load bearing walls making up the bulk of the work.

The most common forming system is comprised of vertical plywood panels cut to

dimension using electric power saws. The most common saw in use is referred to as a "worm-drive saw." The worm-drive saw is so called because the motor is at right angles to the blade which requires the use of a worm gear arrangement to turn the blade. This type of saw is usually much more powerful than the standard direct drive circular saw. It is heavy (about 8.6 kilograms (16 pounds)) and poorly balanced from an ergonomic perspective. The weight of the saw is concentrated in front of the handle. The repetitive lifting of this type of saw from the ground to the work bench may present an ergonomic hazard to some workers.

Saw horses constructed at the beginning of the job are generally designed to waist height of the builder. Shorter workers who later use these saw horses may be required to use a working surface that is above waist height. Likewise, tall workers may have to stoop to use the sawhorses. The ergonomic hazards of using heavy saws are compounded by this situation since the worker must lift the tool instead of leaving their arms fully extended and maximizing the load borne by the work surface.

Snap tie holes are bored through panels using an electric drill. Snap tie spacing is dependent on the size of the form, with large forms designed to hold large amounts of concrete typically using a spacing pattern of holes every 30 to 61 centimeters (12 to 24 inches) both vertically and horizontally. Use of electric saws and drills appears to expose workers to relatively

low sources of vibration, except in the case of older saws in poor condition which may represent fairly high vibration sources. Short-term vibration from hand tools has not proven to have much effect on task performance by carpenters⁽¹⁸⁾.

Form panels are typically constructed from 122 cm X 244 cm X 1.9 cm (4' x 8' x 3/4") sheets of plywood. The reuse of plywood forms increases their weight because of saturation with moisture and cement. Forms may be constructed of multiple panels thereby increasing their weight. Carrying and setting plywood panels creates ergonomic hazards associated with materials handling. Where large forms are used, especially those with curvature, placing and securing panels using snap ties requires a great deal of exertion in awkward postures. Walers (horizontal pieces of wood 5 cm x 10 cm (2 in. x 4 in.)) are used to brace and align form panels. Finally, forms are braced to wooden stakes driven into the ground using a 0.9 kg (2 lb.) hammer or a sledge hammer. Braces may also be nailed to blocks secured to a concrete slab with "cut" or masonry nails. The use of sledge hammers is likely to place a great deal of strain on the back. The use of 0.45 kg (16 oz) steel shanked hammers to nail into concrete seems to result in absorbance of a great deal of impact shock to the lower arm, wrist and hand. Bent angle hammers have been designed with a 20-40 degree angle to allow hammering with a straight wrist. Research suggests that they could be used to reduce the incidence of hand and wrist disorder among carpenters⁽¹⁹⁾.

Forms must be square, plumb and secure enough to contain the large outward forces exerted by freshly placed concrete. Improper bracing will result in failure of the form or a "blow-out". This results in the escape of wet concrete from the form. When this occurs, workers must manually shovel wet concrete back into the form or into a wheel barrow to be discarded. The weight of manually manipulating concrete with shovels and wheelbarrows requires significant upper body strength.

Finally, after the concrete has set-up, forms must be stripped. Wrecking bars, 61 cm X 122 cm (2 X 4 foot) levers and sledge hammers may be used to remove braces and panels. Large panels are often difficult to remove. Carpenters may have to use a great deal of body force (often from small elevated work surfaces such as the top of the structure being formed) to break the bond between the concrete and plywood. Because of the prevalence of form construction and the relatively high degree of ergonomic hazard associated with this type of work, this area of new construction warrants much greater attention

STRUCTURAL STEEL WORK

Once the foundation work is completed, structural steel is erected. Steel columns are bolted to concrete footings and then horizontal I-beams are attached to form the steel skeleton of the building. Ironworkers erecting the steel are like aerial tight rope walkers because of the

demanding nature of the work, requiring both skill and balance. They shimmy up steel columns and walk out onto 15.25 cm (6 inch) beams to capture suspended steel beams. Columns and beams are aligned and bolted together several dozen feet in the air while straddling beams. Corrugated metal or plywood decking is then placed between the cross-beams. Some welding is also done from hanging platforms which afford a better height and position for welding, but a small workspace. An ergonomic assessment of structural steel work was conducted on the site⁽²⁰⁾. Awkward postures, occasional high force requirements, static postures, repetitive movements, use of pneumatic tools, and lifting were suggested as potential ergonomic problems for the structural steel workers, particularly the bolting crew. Welding of the decking in place requires a lot of squatting and kneeling as well.

Since structural steel is lifted into place by cranes, crane operators are also an essential part of this operation. Crane operators have ergonomic problems relating to the movement and placement of dangerously heavy loads with extreme precision. Since materials are commonly placed a significant distance (and often out of sight) from the crane, a worker must hand signal the operator. This places high demands on visual acuity and ability to see hand signals. They also have whole-body vibration and some noise exposure.

CONCRETE REINFORCEMENT

Once the structural steel and decking is in place concrete floors are poured. For ground floors, the area is first filled with gravel which must be spread with flat rakes. Then, a mat of rebar is constructed by laying steel rods about 1 foot apart in both directions. Perpendicular intersections are attached by ironworkers (or rodmen) using tie-wire. Spools of tie-wire are worn on workers' belts. Sections of tie wire are pulled from the spool and cut using "side-cutter" pliers and twisted around the rebar intersection.

Ironworkers may stay continuously bent over, rarely standing up straight as they move across the mat. A survey of Swedish workers found reinforcement workers bent over up to 58% of their work time while working on floor slabs⁽²¹⁾. Tying steel rebar involves a great deal of rapid repetitive twisting of the wrist. Representatives of ironworkers have noted, in discussions with the authors, ganglion cysts among their members.

Reinforcement work also presents ergonomic risks associated with manual materials lifting since iron reinforcement bars (rods or "rebar") are heavy and bulky (long and thin) and often must be carried from remote ground level stock piles. Rods are about 9.2 meters (30 feet) long and weigh from about 0.2 kg (0.4 pounds) per 0.3 meters (1 foot) for the smallest rods to 6.2 kg

(13.6 pounds) per 0.3 meters (1 foot) for the largest rods. The most commonly used rods (#5 size rods) weigh about 0.45 kg (1 pound) per 0.3 meters (1foot) and thus weigh about 13.6 kg (30 pounds) each. Workers commonly carry three rods at a time for a weight of 40.8 kg (90 pounds). Often two workers carry the rods together because they are so long and difficult to handle. Workers also must balance themselves while walking on mats of rebar a few centimeters above the ground.

Studies of concrete reinforcement workers have demonstrated the serious risks of ergonomic injuries that they face. A 1974 study of Finnish workers reported a larger percentage of concrete reinforcement workers suffering harmful effects from difficult work postures than any other group⁽²²⁾. Studies by Wickström, et.al. published in 1978 showed 84% of concrete reinforcement workers reporting back trouble, 42% sciatica, 33% lumbago⁽²³⁾. About half reported aches, fatigue and stiffness from an ordinary workday, with 20% reporting sharp pain⁽²³⁾. Sciatica was correlated with length of employment but disc degeneration was not, possibly due to early retirement of injured workers⁽²³⁻²⁷⁾. A follow-up study in 1989 found a higher risk of sciatica among workers with lumbar disc degeneration⁽²⁸⁾. The authors conclude that more preventative measures are needed to prevent problems among concrete workers.

Some work practices and tools have been developed to redesign the reinforcement work environment. Pulling rebar out of ground level stock piles is one of the more difficult tasks for

workers. A rebar storage device, for example, brings the rods closer to the work area, resulting in shorter carrying distances, and stores rods at waist height, making them easier to pick up. A "tying automat" (a metal extension device with a triggering handle at waist height) is also in use in Sweden to allow workers to tie rods from a standing height⁽²⁹⁻³⁰⁾. Use of welded fabric nets instead of reinforcing bars has also been suggested to reduce the requirements for tying⁽³¹⁾. Larger diameter bars also reduces the ergonomic stress on all parts of the body. This and other alternative methods for floor reinforcement have been investigated by the Swedish Cement and Concrete Research Institute⁽³²⁾.

CONCRETE FINISHING

When reinforcement work is completed, concrete is then pumped onto the deck from a large diameter hose held in place by a crane. Freshly poured concrete is then spread out and pushed into place using hand rakes called "come alongs". The surface is smoothed by dragging a "straight edge"(a 5 cm x 10 cm (2 in. x 4 in.) piece of wood with handles on the top edge) in a zig-zag pattern while standing in 15-20 cm of wet concrete. Hand trowelling is then done around edges and hard-to-reach areas. A hand-held vibrator is used to distribute the concrete into walls and edges and prevent "honey-combing". A long-handled "float" is used to finish the surface from the side of the work area. Lastly the surface is mechanically finished again after it has partially dried.

Pouring and finishing concrete requires significant lower back, leg and upper body strength⁽¹⁷⁾. Raking the concrete on the surface is strenuous work due to the viscous nature of the concrete. Use of the straight edge for smoothing the surface requires less force (since less concrete is moved) but requires working in a bent over posture, at ankle height, and twisting of the spine. Trowelling the edges is also done in a bent over posture. The hand-held vibrator is a bit bulky, requires static postures, and results in some hand-arm vibration.⁽³³⁾ Use of the float was awkward due to the long handle (approximately 3 meters(10 feet) long) used to reach the center of the work area, but the handle was hollow aluminum and very light. Mechanical finishing of the surface after it has dried is done with a machine similar to a floor buffer. The handles on the machine were at a proper height for the operator, but force was required to guide and steer the machine. Also, the machine was heavy and workers had to drag the machine onto the work area before the power was on⁽¹⁷⁾. Forces of over 45 kg (100 pounds) were measured to drag the machine over the floor. It may also present additional stress for other workers who are different heights since the height was not adjustable.

Some ergonomic improvements can be made in concrete finishing work. One device called the "Freedom Straightedge handle" attaches to the straight edge used to smooth the surface of the concrete and allows the job to be done from a standing position⁽³⁴⁾. Use of additional plasticizer in the concrete has also been recommended as a way to reduce stress by making the

concrete flow easier⁽²⁹⁾.

Concrete Removal

In some cases concrete that has already hardened must be removed and repoured. On the job we studied, for example, a stairway had to be broken up and redone. Removal of concrete is accomplished by hand-held pneumatic tools such as chipping hammers and jack hammers. Chipping hammers are generally too short, forcing workers to stoop over. They are also associated with high amounts of hand-arm vibration⁽³⁵⁾. Jack hammers are extremely heavy and noisy and a significant source of vibration. Since jack hammers must be constantly lifted onto concrete surfaces, their use places a great deal of strain on the back.

Use of pneumatic tools has long been associated with disease such as vibration white finger (Raynaud's syndrome)⁽³⁶⁾. One of the first reports in the U.S. on "spastic anemia" in stonecutters using pneumatic tools was published in 1918 by Dr. Alice Hamilton⁽³⁷⁾. Vibration exposure also has been shown to result in a higher risk of shoulder tendinitis among construction workers using rock drills⁽³⁸⁾. Vibration-dampened chipping hammers are available⁽³⁹⁾ but are not in widespread use in America. Vibration is a common problem of hand-held power tools in construction⁽³⁵⁾.

SPRAY FIREPROOFING

After the metal and concrete structure is substantially completed, the structure is fireproofed. A mineral wool is sprayed on to the steel and undersides of the decking. The spraying operation is noisy and results in mineral wool exposure to workers but does not appear to present many ergonomic problems. However, the hose used to spray the material may present some arm and shoulder fatigue, neck pain and vibration to the operator, who must hold the hose up in the air throughout the work shift.

INTERIOR WORK

Once the structure is in place, work can begin on the interior of the building. This includes installation of the mechanical system (heating, ventilation and air-conditioning system, HVAC), the plumbing system, the electrical system, interior walls, trim and elevators.

Sheet Metal Work

A survey of sheet metal workers in Sweden by Bygghälsan in 1990 found that a large percentage of their time is spent in poor work postures⁽⁴⁰⁾. They determined that if they spend more than an hour a day bent double, they have a 1.5 higher risk of back problems. Four hours

a day in that position increases the risk to 3.6 times. Kneeling more than one hour a day doubles the risk of knee injuries. Wrist injury risk increases among sheet metal workers by 2.5-2.9 times with frequent tool use (more than 1 hour a day).

At the site we were on, sheet metal workers primarily hung ductwork for the HVAC system and insulated it with fiberglass duct insulation on the outside. The ductwork was fabricated offsite in sheet metal shops, brought to the site and hung from the ceiling with metal straps. Straps were shot into the ceiling with powder-actuated tools (Hilti guns) which produce a lot of hand-arm stress from recoil and shoulder stress from constant use overhead. High impact noise is also associated with use of these tools. Researchers have developed a bolt gun support belt which can absorb and distribute the impact of these tools and reduce shoulder and arm stress⁽⁴¹⁾. This work entails spending most of the time working overhead with raised arms, which is very stressful to the shoulders and back. The ductwork was, however, raised to proper height and positioned using a mechanical lift with a hand crank.

Pipe-fitting and Plumbing

Pipe installation in the building involved three different crews. First, the steamfitters, installed the piping for the heating and air-conditioning system. The second installed the water and waste pipes. A third crew, the sprinkler fitters, installed the sprinkler system. Water pipes are often at odd angles and in cramped spaces. Pipes for the mechanical systems are mostly in the mechanical rooms (boiler room and penthouse mechanical room). They require extensive welding of pipe sections to ensure they can withstand the pressurized system. Steam pipe fabrication involves welding of numerous pipes and fittings. Typically, short sections and elbows are tack welded into place on pipe stands elevated to waist height. Pipes are then joined together in place to form an intricate maze of pipework. Filling in the tack welds with a continuous weld bead involves maintaining a static posture for long periods of time. Striking and maintaining an arc requires holding the electrode a precise distance from the surface being welded, forcing the welder to hunch over the work. Pipe-fitters consequently bend over pipe while working for long periods of time. Plumbers installing water and waste pipe spend a large part of their time on their knees installing pipe at ground level. Most of the work is done at ceiling level for the sprinkler installation. Plumbing and pipefitting also requires significant amounts of materials handling. Pipes and fittings can be very heavy, depending on their composition, diameter, gauge and length. Some hoists and dollies are available for moving larger diameter and heavier pipe.

A survey of ergonomic problems in the plumbing sector in Sweden (called the KRAM

project) was completed in 1983⁽⁴²⁾. They identified a high level of stress on the neck and shoulders among plumbers, primarily from overhead work. They recommended that, whenever possible, piping be located on the walls of utility tunnels, rather than overhead, resulting in less strain and higher productivity.

Electrical Work

Electricians have been one of the least studied trades. Researchers at George Washington University recently completed a survey showing a high rate of musculoskeletal disorders among electricians⁽⁴³⁾. On the worksite we studied, they often worked in cramped work postures. Fine motor work was required in making connections at electrical boxes while large effort was required for pulling cables through conduit. Making connections requires extensive use of hand tools, e.g., pliers and screwdrivers, often in cramped spaces such as in ceilings above ductwork and pipes. This presents a high risk for wrist injuries⁽⁴⁴⁾. Improved designs for screwdrivers such as better grips, are available⁽⁴⁵⁾, but even these are stressful to use. The stress on the arm and shoulder from use of screwdrivers by electricians has been shown to decrease significantly by the use of battery-powered screwdrivers and the use of TORX[®] (with six-sided holes) screws (rather than Phillips head)^(44,46). A slot head or Phillips head screw requires a higher grip force to counteract the tendency of the screwdriver to slip out of the head of the screw. By using a

TORX® head, which have a much deeper six-sided slot, the grip force is reduced significantly. The use of powered tools and TORX® screws increases productivity as well⁽⁴⁶⁾. TORX® head screws are in common use in the automotive industry, but not widely used in construction in the U.S.. Cordless rechargeable screwdrivers, however, are widely used and accepted throughout the industry. Use of drill motors and pliers also require significant flexion of the wrist.

Drywall stud installation

Prior to installation of drywall carpenters shoot floor and ceiling plates into concrete using a powder-actuated tool. Shooting floor plates may involve excessive bending or work on the knees. Because of the height of the ceilings (about 3 meters or 10 feet in this instance), installation of ceiling plates is done on a scaffold or using an extension on the anchor gun. The worker still had to support the weight of the gun while working overhead. Also it is difficult to do work which demands accuracy at long distances from the surface. Researchers in Sweden have designed a "drill stand"^(Fig. 1) to hold tools for use overhead, supporting them on a base on the floor⁽⁴⁷⁻⁴⁸⁾. They also have developed a waist belt which absorbs the kickback from the tool and distributes the energy around the waist, reducing stress on the arms and shoulders^(41,47).

Elevator Construction

The building being studied contained three elevators. Elevator construction requires many awkward work postures because heavy materials must be manipulated within a narrow vertical shaft. Heavy materials must also be handled near deep shafts without falling over the edge. A symptom survey of installers in Sweden found 67% of installers had back trouble, 45% had knee trouble and 21% foot trouble in the preceding 12 months, higher than other construction workers⁽⁴⁹⁾. They recommended improvements such as: advance planning and grouting-in of guide brackets in shafts, lifting hooks in the ceiling of the shaft, greater use of carts and dollies (e.g., for use in transporting doors) and hydraulic lifts on carts.

ROOFING

Before the interior walls of the building are begun, the roof must be put on. This particular building used a "hot built-up roof". Hot asphalt was spread on a plywood surface, covered by fiberglass insulation and four alternating layers of hot asphalt and felt paper and finally gravel. Roofing poses many different ergonomic hazards⁽⁵⁰⁾. A study of ergonomic problems of roofers in Sweden identified materials handling as the primary problem, moving large bulky materials around on the roof⁽⁵¹⁾. On the job we studied, 19 liter (5 gallon) buckets of hot tar were carried from the kettle to other parts of the roof by hand. Buckets had poor handle design which made them uncomfortable to carry and hold. Mops soaked with hot tar were

used to spread the material and were heavy to push around, especially as the material viscosity increases and it gets stickier. The kettle operator had to manipulate large heavy (45 kg (100 lb.)) tubes of asphalt and break them into small pieces using an ax to deposit them into the kettle. This stress could perhaps be reduced if companies supplied smaller stock. Workers must also spend a lot of time on their knees installing insulation and paper. Researchers have recommended greater use of cranes and dollies, better planning of jobs with regard to materials placement, more two-person lifting of materials and sessions with workers to develop new work methods.⁽⁵¹⁾

Other roofing systems, such as single ply roofing, offer ergonomic hazards as well. Roofers fastening single ply roofing systems in place must work in a bent over posture most of the time. A new Dutch device has been designed to allow for this work to be done from a standing height.⁽⁵²⁾

WORK ON BUILDING EXTERIOR

The exterior of the building that was studied was made up of metal panels attached to the building frame and caulked together to maintain a water-tight seal. The work was mostly done off of a hanging scaffold. The metal panels were relatively small and thin gauge and consequently were not very heavy to lift or install. Other buildings can use heavy metal "sheet

cladding" which presents a greater ergonomic risk. Researchers have devised a "double decker" scaffold with a sheet cladding storage device overhead⁽⁵³⁾. Sheets can then be dropped into place, reducing the amount of lifting required. The scaffold is motorized and can be moved up or down incrementally.

The building being studied also had granite cladding on some exterior surfaces which often had to be trimmed to fit and fastened to the building. This required a lot of lifting and hoisting of heavy panels onto scaffolds. Trimming was accomplished with small stone cutting saws which were hand-held and, in some cases, circular saws with masonry blades, which were heavy and awkward to use. Fastening was done using screw guns. This work presented a risk of back injury and hand/wrist problems.

Exterior exposed concrete surfaces on parts of the building were also sandblasted to achieve a mottled look similar to the granite finishes. This may have presented a risk of hand-arm vibration to the blaster on the job and required heavy lifting for the "pot tender", the worker feeding sand into the hopper. The pot tender stacked the bags up on the side of the hopper to reduce the amount of bending required to pick up the bags, but there still was a considerable materials handling problem that could have been reduced.

Window installation requires considerable materials handling. The windows on this building were not extremely large and could be handled by 2-4 people easily using suction cup handling devices. On jobs which are short staffed the risk of back injury among these workers would be higher. Devices have been designed for mechanical handling of windows⁽⁵⁴⁾. Windows must then be held in place with caulking. Inserting the caulking between the glass and the window frame requires considerable hand force and dexterity, making it a candidate for ergonomic problems.

Some of the exterior walls on the job we studied were finished or surfaced with concrete for appearance, rather than leaving a masonry wall showing. The worker trowelled concrete onto the surface and smoothed it out with a straight edge. Trowelling requires significant wrist flexion. The weight of the concrete on the trowel could present a potential hazard to the wrist from this repetitive work. In addition use of the straight edge requires force to be applied to a vertical surface as the tool was moved horizontally over the surface with a twisted trunk posture. The amount of force is likely to increase as the concrete sets.

WALLS AND CEILINGS

Once the exterior of the building is substantially completed and the roof is on, intensive

work begins on the interior of the building, since it is now protected from the weather.

Scaffold Erection

Work on the interior of the building may require the erection of scaffolding. This particular building, for example, included a three story atrium with a skylight. Work in the atrium required the erection of scaffolding. Erecting scaffolding, by its nature is ergonomically stressful in that, like steel erection, a structure is being built where none exists. Scaffold frames are made in metal sections which are pinned together. Wooden or metal planks are then added. The sections must be manually hoisted overhead to go on top of the base section. Planking must be hoisted up to the top section from below. This requires extensive overhead lifting. Scaffold frames are often of such dimensions that it is difficult for smaller workers to carry. Workers erecting scaffolding all day handle 3000-4000 kg of weight a day⁽⁵⁵⁾. Workers disassembling scaffolding, which is three times faster, handle much higher amounts of weight, but much of it is lowered to the ground. Weights must be handled while balancing on the steel frame, which provides tenuous support.

Researchers have designed a scaffold which is easier to assemble, and hooks or snaps together, but studies have shown it to be more stressful to the body to assemble because it is not

as sturdy and becomes damaged more easily⁽⁵⁶⁾. They recommend that proper training be given to workers on proper work postures to reduce risk of injury. Emphasis should also be placed on the use of block and tackle or hoisting devices, where possible to lift up planks or scaffold sections.

Drywall installation

Most of the interior walls of the building were made of drywall. Drywall has essentially replaced plaster and lathe construction for this use. Drywall normally comes in sheets that measure about 122 cm (4 feet) wide by 244-366 cm (8 or 12 feet) long and are about 1.6 cm (5/8 inch) thick. The boards weigh about 8.6 kg/sq. m (1.76 lbs/sq.ft.) or from 25.6 kg (56.3 lb) to 38.4 kg (84.5 lb) each.. Boards must be cut to dimension and accommodate electrical fixtures, windows and doors. Long straight cuts are done using a utility knife to score the face and then bending the board back until it breaks. Workers often use their knees to "break" the back of the board. A keyhole saw is used for cutting fixture holes. Knives and saws are not ergonomically designed and likely produces considerable stress on the hand and wrist. This places repetitive pressure on the palm. The knife is used to cut through the paper face and then the board is snapped along the cut. Cutting tools exist which fit over the edge of a board and can be preset for depth. These are equipped with a handle which allows them to be comfortably pulled while

cutting⁽⁵⁴⁾. Moving boards from where they are stacked on pallets for storage to where they are being hung produces considerable stress on the back, due to both the size and weight of the boards.

The stress associated with transporting the sheets to the wall can be reduced by the use of carts and dollies as much as possible. Dollies that are easy to maneuver on construction sites have been designed for the transport of drywall sheets and are available⁽⁵⁴⁾. In Sweden, the risks posed by this operation have been addressed by reducing the width of the boards, and consequently their weight⁽⁵⁷⁾. Board width has been reduced from 1200 mm (almost 4 feet) to 900 mm (almost 3 feet). Studies have shown that the reduction in width makes it considerably easier to handle the boards and reduces stress on the back⁽⁵⁸⁾. Work with the smaller boards resulted in lower heart rates among workers⁽⁵⁸⁾. The only concern raised about the use of smaller boards was with the increased amount of fastening required from the additional boards. The additional cost of the boards was offset by lower waste and lower anticipated absenteeism and illness costs. Use of smaller boards will also increase the number of joints which must be taped and finished. Risk of back injury among drywall installers can also be reduced by proper training and the use of carrier handles⁽⁵⁹⁾.

Fastening the boards to the metal studs is accomplished using electrical screw guns.

Boards are fastened around the edges and on stud centers, necessitating both an overhead reach and below the knee work. Fastening requires holding the screw gun level and exerting moderate force in the horizontal plane. This is difficult for the overhead and under knee positions. We observed a 90° flexion of the wrist for some wall work. Screw guns have been developed with a swivelling handle which may allow greater ease in fastening in these difficult positions⁽⁵⁴⁾. Another study suggested that "micro pauses" or short breaks after every few screws (10 seconds every other tightening) reduces stress and actually increases productivity⁽⁶⁰⁾. Workers were more productive if they had these micro pauses as they had less fatigue during the workday.

Installing ceiling drywall requires lifting sheets overhead and holding them in place until fastened. This places enormous stress on the arms and shoulders. Plasterboard lifts^(Fig. 1) exist which can crank the board to the desired height and hold it in place for fastening^(47,54). While they were not used on the job we studied, they could greatly reduce the risk of injury from this operation. Lifts, however, would be difficult to use in stairways.

Once the drywall has been hung, it is "taped". A taping compound is applied to the joints using a wide taping blade. This job requires a lot of wrist flexion and work over shoulder height. It is generally done on stilts to reach the joints at the top of the wall. Stilts used are about 60 centimeters (2 feet) high and strapped to the leg. The use of stilts transfers weight for balance

from the feet to the knee joint and places greater stress on the knee joint as the worker moves around on them, particularly when bending down to tape on lower levels without adjusting the stilts. While no studies have yet been done among these workers, it would appear that the use of stilts would place workers at increase risk for knee injuries. They also may increase the likelihood of trips and falls.

Drywall finishing is a several step process, during which the joint compound and taping is been applied and allowed to dry. In some cases, several subsequent coats are used to obtain an even finish and to allow for some expansion and contraction. The process is completed by sanding the joint down to a smooth finish. The sanding is accomplished by hand sanding using a hand-held block or a long-handled pole with a piece of sandpaper on the end of a swivel plate. The sander moves the sandpaper up and down the joint (or back and forth for horizontal joints) until a smooth finish is achieved. This repetitive sanding is done throughout the shift. Since drywallers often are paid on a piece rate system, work shifts commonly exceed eight hours a day. This places stress on the back, arms and wrist as pressure has to be applied to the paper to create the friction for sanding. Sanding high and low areas requires difficult angles for applying the proper force. Use of electric sanders would reduce the force required, but may gouge up the drywall. This would also increase the risk of hand-arm vibration.

Painting

Once the drywall has been installed and finished, the surface can be painted. Sometimes paint is spray-applied, but more often long-handled rollers are used. Long-handled rollers present similar problems as the drywall joint sanders. Overhead painting of ceilings places considerable stress on the arms and shoulders as well as the neck. Research has shown that a simple flange (called a "painters disk") added to the pole handle allows the worker to support the pole more easily and reduces the requirements for grip force⁽⁶¹⁾. This greatly reduces the stress from this static load. An inflatable neck pillow can also be used to reduce stress on the neck from constant work overhead⁽⁶²⁾.

The design of paint buckets also presents ergonomic problems for painters. The buckets are heavy, containing fluid materials which shift as you carry them. Lids are hard to open and the handles are poorly designed. A major effort to redesign these packages was undertaken by the Swedish Packaging Research Institute. It resulted in newer easy to open lids, oval or rectangular buckets and larger diameter (20-25 mm, about 1 in) handles⁽⁶³⁾. Painter's putty bags were also studied and redesigned, including a reduction in size from 50 kg (110 lb) to 25 kg (55 lb) per bag and smaller bags for patching and repair jobs. These new designs are not in use in the U.S. to our knowledge.

Drop ceiling installation

Installation of the ceiling grid and drop ceiling is one of the last steps in completing the interior space. Once the ceiling is installed it becomes much more difficult to work above the ceiling on the building systems, because of cramped work spaces. Drop ceiling installation requires a lot of overhead work, although the components are not particularly heavy. Hangers are suspended from the concrete flooring above and tracks are tied to those hangers. Use of hand tools, such as tin snips and pliers, may also present ergonomic stress to the hands and wrists by cutting into the palms or requiring twisting of the wrist. Stress from hand tightening of screws can be reduced by the use of better ergonomically designed screwdrivers and electric screwdrivers⁽⁴⁴⁾. Models are available which have improved handles of the proper diameter, surface area and length which allows for better grip and more torque.

FLOORS AND CARPETING

Concrete floors are generally finished by the application of vinyl, ceramic tile, terrazzo or carpet. The finishing of the floor requires constant kneeling and bending. Glue is generally spread on the floor by hand using a trowel and the tiles set in it. Long-handled glue spreaders have been designed to allow the job to be done from a standing position^(Fig. 2), but generally the

work is done in a kneeling position.

Carpeting must be stretched in order to obtain a perfect fit free of buckling. Stretching is most commonly accomplished using a "knee kicker", as was used on the job we studied. The knee kicker is a metal bar with a rubber bumper on one end and cleats on the other that dig into the carpet. The carpet layer bangs the knee kicker with his or her knee stretching the carpet. This tool is popular because it is convenient and lightweight. Studies by NIOSH, however, have shown that use of the knee kicker results in very high rates of knee injuries⁽⁶⁴⁻⁶⁶⁾. Carpet layers only represent 0.06% of the U.S. workforce and yet submit 6.2% of all compensation claims for knee injuries. Carpet layers have high incidence rates for bursitis, needle aspiration of fluid from the knee, and skin infections of the knee. Bursitis is directly related to use of the knee kicker. Other knee problems, such as thickening of the prepatellar or superficial intrapatellar bursa, relate to the extensive amount of kneeling required by the job⁽⁶⁷⁾. Researchers recommended that workers be trained and required to use mechanical power stretchers which are available for the same job.

Workers do wear knee pads when working, but the pressure of kneeling still places great stress on the knees. Devices are marketed which combine a knee pad with a spring seat to help support the weight of the trunk rather than placing all that weight on the knee joint. Adjustable

stools with wheels or sit/stools may also be useful in such situations⁽⁵⁴⁾. One other solution which exists is overalls with knee pads pockets in the front. Workers may dislike wearing knee pads that must be strapped on as they may cut off circulation. This solution avoids that problem by having the pad slip into a pocket in the front of the overalls.

The movement of flooring materials, such as rolls of carpeting, requires a great deal of materials handling, which should be done, as much as possible, by the use of carts and dollies. Special dollies have been designed for transporting of carpets⁽⁶⁸⁾.

Tile and terrazzo work also requires constant kneeling, placing workers at high risk of knee and back injuries. In some cases, the weight of the tiles to be set can be substantial and considerable work must be done to finish the surface. Finish work also requires a lot of hand and wrist motions and may place them at greater risk of wrist injury.

FIXTURES AND TRIM AND FINISH WORK

Ceiling fixtures, bathroom fixtures, doors and cabinets must also be installed requiring work overhead, movement of heavy objects and cramped work postures.

Trim work

When most of the interior space is completed, final trim work is done. This requires many awkward postures. Some of this work, such as installation of base boards and shoe molding, is done at floor level and requires a lot of kneeling. Border drill stands^(Fig. 2) have been designed to allow drilling at floor level from a standing position, but they are not widely available or used^(47,54). Hanging interior doors requires considerable use of the back muscles since the weight of the door must be held up while lining up the hinges. The use of a foot lever especially designed for hanging doors reduces the back strain significantly. Devices also exist for the mechanical handling of doors⁽⁵⁴⁾ which can raise and lower the door to the proper height and position it in place.

PAVING AND OTHER EXTERIOR WORK

Other work is required outside the building, including construction of walkways, landscaping and parking lots. While much of the exterior work on the job we studied was poured concrete. The walkways were made of paving stones which were often cut to fit and set in place with some precision. When cutting stone to size, workers repeatedly bent over and picked up a large gasoline-powered masonry saw to cut small blocks held secure by their feet. The weight

of the stones and the masonry saw present a potential risk of back injury. This was compounded by the fact that, being a walkway, the work proceeds at ground level. Tampers were also used to pound stones into place. Dollies which can lower heavy stones into place have been designed for this type of work⁽⁵⁴⁾. Stationary masonry saws are available as well which would prevent repetitive lifting of the portable saw and use of the feet to secure blocks while cutting.

Asphalt paving observed on the investigated construction site involved a crew of about 5-7 workers. The preliminary task involved level grading of surfaces to be paved. Gravel is trucked in and spread using heavy equipment. When the ground is sufficiently dry and graded, hot asphalt is delivered. The principal mechanism for asphalt paving is a piece of heavy equipment called a "paver". The paver follows closely behind a dump truck that slowly delivers hot asphalt. An equipment operator drives the paver over the fresh asphalt. While two workers sit on the back of the paver adjusting the grade to which the asphalt will be compressed. A hand operated gasoline powered machine is also used for paving edges. This machine is similar to an earth tamper. One or two workers may also walk along the paver using the edge of a rake to screed freshly paved surfaces. Workers riding the paver all day are exposed to whole body vibration, as is the dump truck operator. Hand-arm vibration is also a concern for the worker operating the hand-held paving machine. Better, more ergonomically designed, paving machines have been introduced in the Netherlands which reduce the workload of pavers⁽⁶⁹⁾.

OTHER

Granite panels were installed in the atrium and lobby areas of the building under study. The panels were heavy and required transporting and lifting while they were fastened into place, which represented a potential ergonomic risk to workers.

Once the exterior of the building is completed, much of the materials handling within the building is accomplished by way of the stairs. Small batches of concrete, for example, may move up the stairs for hand placing in an area. The elevators are generally not completed until late in the process and their use for materials handling is limited by the size of the elevator, which may be too small for carrying building materials, although some buildings have exterior hoists for building materials while they are under construction. Movement of materials up and down stairways is very risky ergonomically. Vision may be blocked by the materials, resulting in a fall and tripping risk. Stairways are also fairly narrow, making it difficult to carry and maneuver heavy loads.

Final clean-up of the building requires considerable materials handling of scrap and hand-sweeping of debris. This also presents a materials handling risk to workers. Materials handling has been shown to be a significant risk factor for accidents in construction⁽⁷⁰⁻⁷⁵⁾. A more

systematic approach to the organization of the construction process has been recommended to reduce accidents due to materials handling.

SUMMARY AND CONCLUSIONS

The evidence exists that construction workers have high rates of ergonomic injuries. We have identified a number of ergonomic hazards associated with construction of a new office building. We have also identified possible interventions that have been developed. Hazard identification is the first step in exposure assessment. It is our hope that this review will point researchers in the right direction to more in-depth study of construction ergonomics issues. In construction, unlike industrial worksites, the work station is not fixed and cannot be modified on a permanent basis. But solutions do exist through tool and materials engineering. Tools should be modified to reduce vibration and wrist flexion. Tools that reduce the amount of floor level and overhead work are also needed. The Swedish solution of minimizing the width of drywall boards to reduce materials handling requirements is a good example of the important role materials engineering can play in the construction area. We need to promote the use of tool and materials engineering solutions among manufacturers and contractors. As new tools and materials may require slightly different application methods, workers should be trained in their use and the benefits of their use on worker health. With this information, we have hopefully taken one small step towards addressing the huge problem of ergonomic injuries in construction.

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REFERENCES

- 1) U.S. Department of Labor, Bureau of Labor Statistics: "Occupational Injuries and Illnesses in the United States, 1989", Bulletin 2379, Washington, DC, U.S. Government Printing Office (April 1991).
- 2) Burdorf, A.: Exposure Assessment of risk factors for disorders of the back in occupational epidemiology. Scand. J. Work Environ. Health 18:1-9 (1992) .
- 3) Guignard, J.C.: Evaluation of Exposures to Vibrations. In Patty's Industrial Hygiene and Toxicology Volume III: Theory and Rationale of Industrial Hygiene Practice, edited by L.J. Cralley and L.V. Cralley. New York, John Wiley and Sons, p. 480-485, 1979.
- 4) National Institute of Occupational Safety and Health: Morbidity Patterns among Heavy Equipment Operators Exposed to Whole Body Vibration- 1975: Follow-up to a 1974 Study by R.C Spear, C.A. Keller, V. Behrens, M. Hudes, and D. Tarter (DHEW/NIOSH Publication 177-20). Cincinnati, OH: National Institute of Occupational Safety and Health, November 1976. Cited in "Evaluation of Exposures to Vibrations" by J.C. Guignard. In Patty's Industrial Hygiene and Toxicology Volume III: Theory and Rationale of Industrial Hygiene Practice, edited by L.J. Cralley and L.V. Cralley. New York, John Wiley and Sons, p. 480, 1979.

- 5) Bergöö, W.: Operator Seats- A Neglected Work Environment. English abstract in Bygghälsan Bulletin 1987-05-01, p. 44-45 (1987).

- 6) Gustafson-Soderman, U.: The Effect of an Adjustable Sitting Angle on the Perceived Discomfort from the Back and Neck-Shoulder Regions in Building Crane Operators. Applied Ergonomics 18: 297-304 (1987).

- 7) Freivalds, A.: Ergonomics of Shovelling and Shovel Design- a review of the literature, Ergonomics 1:3-18 (1986).

- 8) Product literature for Ergonomic shovels, "ERGONOMIC- When You Think About Tools", Norbergs Motala, Vitergatan 7, S-591 32, Motala, Sweden.

- 9) Cederqvist, T.: "Jämförande studies av två skyfflar: En biomechanisk och electromyografisk studies med avseende på konstruktion och arbetsteknik", research report from Bygghälsan, (November 1988).

- 10) Hedlund, G.: "A Study Comparing the Amount of Force Exerted on Musculoskeletal Tissues When Using a Short Verses a Long Handled Tool," Farmers Health Society, Vimmerby, Sweden (1992).

11) Jørgensen, K., B.R. Jensen, and M. Kato: Fatigue development in the lumbar paravertebral muscles of bricklayers during the working day. Internat. J. of Indust. Ergonomics 8:237-245 (1991).

12) Jäger, M., A. Luttmann and W. Laurig: Lumbar load during one-handed bricklaying. Internat. J. of Indust. Ergonomics 8:261-277 (1991).

13) Luttmann, A., M. Jäger, and W. Laurig: Task analysis and electromyography for bricklaying at different wall heights. Internat. J. of Indust. Ergonomics 8:247-260 (1991).

14) Holmström, E.: A study of the working movements and work postures of bricklayers when using traditional work methods and when working from a specially designed scaffold. English abstract in Bygghälsan Bulletin 1981-07-01, p. 28-29 (1987).

15) Hammarskjöld, E.: Blocks and Bricks of Masonry- Weight Recommendations- A New Swedish Standard. English abstract in Bygghälsan Bulletin 1987-05-01, p. 18 (1987).

16) Kaiser, R. and G. Linke-Kaiser: "Verbesserung der Arbeitsbedingungen im Mauerwerksbau"

ErgoMed 16: 14-25 (1992)

17) Schneider, S.: "Observations on Ergonomic Hazards at the IAM Worksite 7/15/91", (1991).

18) Hammerskjöld, E., K. Harms-Ringdahl, J. Ekholm, and B. Samuelson: Effect of short-time vibration exposure on work movements with carpenter's hand tools. Internat. J. of Indust. Ergonomics 8:125-134 (1991).

19) Schoenmarklin, R.W.: "The Effect of Angled Hammers on Wrist Motion." Proceedings of the Human Factors Society, 32nd Annual Meeting 1:651-655 (1988).

20) Hart, D. and J. Link: "Ergonomic Job Task Analysis for The Iron Worker", July 29,1991, (1991) .

21) Saari, J. and G. Wickström: Load on back in concrete reinforcement work. Scan. j. work environ & health 4 suppl. 1: 13-19 (1978).

22) Wickström, G., and K. Kaupinen-Toropaonen: "Rakenennusalan työntekijöiden työolot ja terveydentila" Työterveyslaitoksen tutkimuksia no. 91, Institute of Occupational Health, Helsinki,

154 p. (1974). Cited in "Load on back in concrete reinforcement work" by J. Saari and G. Wickström. Scan. j. work environ & health 4 suppl. 1: 13-19 (1978).

23) Wickström, G, K. Hänninen, M. Lehtinen and H. Riihimäki: Previous back symptoms in concrete reinforcement workers. Scan. j. work environ & health 4 suppl. 1: 20-28 (1978).

24) Wickström, G., J. Nummi, and M. Nurminen: Restriction and pain during forward bending in concrete reinforcement workers. Scan. j. work environ & health 4 suppl. 1: 29-38 (1978).

25) Nummi, J., T. Järvinen, U. Stambej, and G. Wickström: Diminished dynamic performance capacity of back and abdominal muscles in concrete reinforcement workers. Scan. j. work environ & health 4 suppl. 1: 39-46 (1978).

26) Wiikeri, M., J. Nummi, H. Riihimäki, and G. Wickström: Radiologically detectable lumbar disc degeneration in concrete reinforcement workers. Scan. j. work environ & health 4 suppl. 1: 47-53 (1978).

27) Wickström, G.: Symptoms and signs of degenerative back disease in concrete reinforcement workers. Scan. j. work environ & health 4 suppl. 1: 54-58 (1978).

- 28) Riihimäki, H., G. Wickström, K. Hänninen, T. Mattsson, P. Waris, and A. Zitting: Radiologically detectable lumbar degenerative changes as risk indicators of back pain. Scan. j. work environ & health 15: 280-285 (1989).
- 29) Adlington, R.S., J.P. Barbier, E.A.P. Koningsveld, P.U. Lehtinen, Å. Lindblad, and O. Messman: Survey of Working Environment in Concrete Construction. Bygghälsan Report 1982-06-01 (1982).
- 30) "Glim-Scan Clip-Chairs", Product literature from Glim Aktiebolag Company in Norrköping, Sweden .
- 31) Hjort, B.: Production-adapted reinforcement. English abstract in Bygghälsan Bulletin 1981-07-01, p. 26-27 (1981).
- 32) Hjort, B.: Placement of floor reinforcement alternative methods- methods development. English abstract in Bygghälsan Bulletin 1984-09-01, p. 8-9 (1984).
- 33) Faborg, K., Janzon, R., and Wall V.: "Concrete Vibration,", english abstract in Bygghälsam Bulletin 1978-05-01, pp. 8-9, (1978).

34) Anon.: "Stigen Straightedge Handle Offers Freedom of Movement", *The Plasterer and Cement Mason*, p.13, December (1991).

35) Jacobsson, B., Nordström, B. and R. Lundström, "Vibrating hand-held machines in the construction industry", *Safety Science* 15: 367-373 (1992).

36) National Institute of Occupational Safety and Health: "Vibration While Finger Disease in U.S. Workers Using Pneumatic Chipping Hand Tools, I: Epidemiology" by D. Wasserman, W. Taylor, V. Behrens, S. Samueloff, and D. Reynolds (DHHS/NIOSH Publication 82-118). National Institute of Occupational Safety and Health, (1982).

37) Hamilton, A.: Reports of Physicians for the Bureau of Labor Statistics. A Study of Spastic Anemia in the Hands of Stonecutters. Excerpt from *Industrial Accidents and Hygiene Series*, Bulletin 236, Number 19, "Effect of the Air Hammer on the Hands of Stonecutters", July 1918, published in Human Aspects of Occupational Vibration by D. Wasserman, Elsevier, (1987).

38) Stenlund, B., Goldie, I., Hagsberg, M. and C. Hogstedt: Shoulder tendinitis and its relation to heavy manual work and exposure to vibration. Scan J Work Environ Health 19: 43-49 (1993)

39) Product literature, Industrial Power Tools catalogue, p. 85-86, Atlas-Copco corporation, 24404 Indoplex Circle, Farmington Hills, Michigan 48331.

40) Bygghälsan Stockholm Region 1990: A health and environmental survey of sheet metal workers. English abstract in Bygghälsan Bulletin 91-09-16 (1991).

41) Wos, W., J. Lindberg, R. Jakus, and S. Norlander, "Evaluation of impact loading in overhead work using a bolt pistol support" Ergonomics 9:1069-1079 (1992).

42) Björk, L.: Survey of working environment in the plumbing sector. English abstract in Bygghälsan Bulletin 1984-09-01, p. 27-30 (1984).

43) Hunting, K., L. Welch, B. Cuccerini, and L. Seiger, " Musculoskeletal Symptoms Among Electricians" American Journal of Industrial Medicine in press (1993).

44) Cederqvist, T. and M. Lindberg: Screwdrivers and their use from a Swedish construction industry perspective. Applied Ergonomics 24: 148-157 (1993)

45) Product literature for Bacho Ergo Screwdrivers, Bahco Verktyg Corporation, S-199 82

Enköping, Sweden.

- 46) Örtengren, R., T. Cederqvist, M. Lindberg, and B. Magnusson: Workload in lower arm and shoulder when using manual and powered screwdrivers at different working heights. Internat. J. of Indust. Ergonomics 8:225-235 (1991). Cederqvist,T., Lindberg,M., Magnusson, and R. Örtengren, "Ergonomiska Jämförelser av Arbeidsbelastning vid Skruvning Manuellt och med Batterdrivna Skruvdragare", "Workload in Lower Arm and Shoulder when Using Manual and Powered Screwdrivers at Different Working Heights", Report from Linköping University Institute of Technology, Linköping, Sweden, (September 1992).
- 47) Rosenlund, E., B. Mäenpää, H. Nilsson, and I. Persson: Ergonomic Equipment in Construction Work. English abstract in Bygghälsan Bulletin 1987-05-01, p. 38-39 (1987).
- 48) Lindberg, J., H. Wos, S. Norlander, and R. Jakus: Support stand for hand-held tools used for overhead work. English abstract in Bygghälsan Bulletin 91-09-16, p. 3-4 (1991).
- 49) Hammarskjöld, E. and K. Henriksson: The Work Environment of Lift Installers. English abstract in Bygghälsan Bulletin 1987-05-01, p. 8 (1987).

- 50) Schneider, S: Notes from Site Visits to Roofing Jobs in California 4/93. (1993)
- 51) Gustafsson, U. and L. Winnell: An ergonomic study of rooflayers. English abstract in Bygghälsan Bulletin 1984-09-01, p. 18-19 (1984).
- 52) Vink, P.: "Application problems of a biomechanical model in improving roofwork" Applied Ergonomics 23(3): 177-180 (1992).
- 53) Glimskär, B., and P. Höglund: A method of assembling sheet-cladding. English abstract in Bygghälsan Bulletin 1983-05-01, p. 26-27 (1983).
- 54) Rosenlund, E.: Bra Byggredskap: Erfarenheter från Rygginstitutets och Bygghälsans arbetsplatskontakter och tester- 89. catalogue of tools from Rygg Institutet, Sweden (1989).
- 55) Kling, H.: Erecting Scaffolding. English abstract in Bygghälsan Bulletin 1984-09-01, p. 22-23 (1984)
- 56) Wagenheim, M., Samuelson, B., and H. Wos: ARBAN- A Force-Ergonomic Analysis Method. In Ergonomics of Working Postures- Models and Mehtods. Edited by E.N. Corlett, J.W.

Wilson and I. Manenica. London: Taylor and Francis, p. 243-246 (1986).

57) Björklund, M., P. Helmerskog, M. Nordberg/Bohlin, U. Söderman, L. Holmqvist, B. Lindblad, J. Mäkynen, and S. Åhrman: 90-sheets for the 90s. English abstract in Bygghälsan Bulletin 91-09-16, p. 35-36 (1991).

58) Isakson H. and J. Kling: Fitting 90 mm and 1200 mm plasterboard sheets- an ergonomic/economic comparison. English abstract in Bygghälsan Bulletin 91-09-16, p. 37-38 (1991).

59) Wählin, M.: Work methods for handling plasterboard and chipboard in building training. English abstract in Bygghälsan Bulletin 1981-07-01, p. 20-21 (1981).

60) Andersson, P.: Manual screw tightening with and without micro pauses. English abstract in Bygghälsan Bulletin 91-09-16, p. 39 (1991) "Manuellt skruvningsarbete utan och med mikropaus: En EMG-studie", Bygghälsan, (1988).

61) Cederqvist, T., "Jämförande studie av erforderad muskelkraft i underarmen vid innertaksmålning utan och med avlastningsstopp- en EMG-studie", Bygghälsan report, (April

1984).

62) Anon." "A pillow to cushion the neck", Working Environment in Sweden 1992: p.40 (1992).

63) Erneling, L.: Easy-to-handle packagings at building sites. English abstract in Bygghälsan Bulletin 1983-05-01, p. 18-19 (1983).

64) Thun, M., S. Tanaka, A.B. Smith, W.E. Halperin, S.T. Lee, M.E. Luggen, and E.V. Hess: Morbidity from repetitive knee trauma in carpet and floor layers. Brit. J. Indus. Med. 44: 611-620 (1987).

65) Tanaka, S., S.T. Lee, W.E. Halperin, M. Thun, and A.B. Smith: Reducing Knee Morbidity among Carpetlayers. Amer. J. Public Health 79(3): 334-335 (1989).

66) National Institute for Occupational Safety and Health: Request for Assistance in Preventing Knee Injuries and Disorders in Carpet Layers, NIOSH Alert, (DHHS/NIOSH Publication 90-104), U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control (1990).

- 67) Kivimäki, J.: Occupationally related ultrasonic findings in carpet and floor layers' knees. Scan. J. Work Environ Health 18: 400-402 (1992)
- 68) Andersson, A. and A. Askergren: Charting of the work environment in the flooring industry. English abstract in Bygghälsan Bulletin 1983-05-01 (1983).
- 69) Berndsen, M.B.: Appliances for Pavioours: An Evaluation of Purchase and Use. Ergonomics 33:361-366 (1990).
- 70) Niskanen, T.: Accident risks and preventative measures in materials handling at construction sites. Labour Policy Studies Series, no. 46, Helsinki, 1993, 72 pp. + appendices, published by Ministry of Labour. ISBN 0787-9458 (1993)
- 71) Niskanen, T. and J. Lautalammi : Accident prevention in materials handling at building construction sites. Construction Management and Economics 7: 263-279 (1989)
- 72) Niskanen, T. and O. Saarsalmi : Accident analysis in the construction of buildings. Journal of Occupational Accidents 5: 89-98 (1983)

73) Niskanen, T. and J. Lauttalammi : Accidents in Materials Handling at Building Construction Sites. Journal of Occupational Accidents 11: 1-17 (1989)

74) Niskanen, T. and J. Lauttalammi : Accident risks during handling of materials at building construction sites. Construction Management and Economics 7: 283-301 (1989)

75) Niskanen, T. : Accidents and minor accidents of the musculoskeletal system in heavy (concrete reinforcement work) and light (painting) construction work. Journal of Occupational Accidents 7: 17-32 (1985)

APPENDIX A : ERGONOMIC RISK FACTORS IDENTIFIED FOR MUSCULOSKELETAL INJURIES IN NEW CONSTRUCTION

The following tables of ergonomic risk factors have been identified for musculoskeletal injuries during new construction work. While all these factors were not observed on the primary site which was the object of this investigation, they are accepted risk factors based on the literature which exists, our experiences on several sites and our discussions with workers. Where there is a supporting reference for the risk factor it has been included in the table in parentheses.

TYPES OF RISK FACTORS

	Awkward Posture	Force	Weight	Repetition	Hand Tools	Static Position	Vibration
New Construction Tasks							
<u>EXCAVATION AND FOUNDATION WORK</u>							
Surveying	X						
Grading w/heavy equipment	X					X	(3)
Trenching by hand	(7-10)	X	X		X	X	
Setting Forms	X	X	X		X		
Compacting Soil	X	X	X		X		X
Sinking elevator shafts	X						X

TYPES OF RISK FACTORS

	Awkward Posture	Force	Weight	Repetition	Hand Tools	Static Position	Vibration
New Construction Tasks							
<u>MASONRY</u>							
Laying blocks	(11-13)		(11-13)		X		
Reinforcing pouring cement in wall cavities	X		(17)				
<u>FORMWORK</u>							
Cut w/worm-drive saw	X	X	X		X	X	X
Use sawhorses	X						
Lifting and bracing forms	X	X	X		X	X	
Shovel concrete after blowouts	X	X	X		X		
Dismantle forms	X	X	X		X		

TYPES OF RISK FACTORS

	Awkward Posture	Force	Weight	Repetition	Hand Tools	Static Position	Vibration
New Construction Tasks							
<u>STEEL ERECTION</u>							
Climbing and connecting	(20)	X			X		
Fastening, tighten bolts	(20)			X	X	X	
Welding	(20)				X	X	
Crane operation	X						
<u>CONCRETE WORK</u>							
Rod tying	(21)	X	X	X	X	X	
Pouring concrete	X	X					(33)
Hand Finishing	X	X			X		
Mechanical finishing	X	X	(17)				X
Removing set concrete	X		X		X		(35-38)

TYPES OF RISK FACTORS

	Awkward Posture	Force	Weight	Repetition	Hand Tools	Static Position	Vibration
New Construction Tasks							
<u>WORK ON STRUCTURE</u>							
Spray fire proofing	X		X			X	
Dust work	(40)		X		X	X	
Plumbing	(42)		X		X	X	
Electrical work	X	(43)	X		X	X	
Elevator installation	X	X	X		X	X	
Roofing		(50-51)	(50-51)				
Carrying buckets			X	X	X	X	
Mopping	(50)	(50)				X	
Installing insulation board	X				X	X	
Kettle work		X	X				

TYPES OF RISK FACTORS

	Awkward Posture	Force	Weight	Repetition	Hand Tools	Static Position	Vibration
New Construction Tasks							
<u>BUILDING INTERIOR</u>							
Scaffold erection	(55)	(55)	(55)			(55)	
Handing drywall	(57-59)	(41,57-59)	(57-59)		(60)	X	
Drywall finishing	X			X	X		
Flooring *							
Glue spreading	X				X	X	
Carpet laying	X	(64-67)	X		X	X	
Material handling	X		X	X	X		
Tile/terrazzo work	X					X	
Ceiling fixtures	(47)		X		X	X	
Painting	(61)			X	(61)	(61)	
Trim work	X				X		
Doors installation	X		X		X		

* Kneeling is a definite problem for this work.

TYPES OF RISK FACTORS

	Awkward Posture	Force	Weight	Repetition	Hand Tools	Static Position	Vibration
New Construction Tasks							
<u>EXTERIOR OF BUILDING</u>							
Sheet cladding	X	X	X		X	X	
Stone, Granite cladding	X	X	X		X	X	
Sand blasting	X		X			X	X
Window installation	X	X	X		X	X	

TYPES OF RISK FACTORS

	Awkward Posture	Force	Weight	Repetition	Hand Tools	Static Position	Vibration
New Construction Tasks							
<u>WORK OUTSIDE OF BUILDING</u>							
Trowel wall	X	X	X		X		
Setting sidewalk							
Cutting	X	X	X		X		X
Setting	X		X				
Asphalt paving							
Raking	X	X			X		
Riding							(69)
Hand held paver	X	X			X		X
<u>OTHER</u>							
Materials handling	X	(70-75)	(70-75)				
Clean-up	X		X		X		

APPENDIX B : SOLUTIONS FOR ERGONOMIC PROBLEMS IN NEW CONSTRUCTION

The following table identifies solutions which exist for some of the ergonomic problems in new construction work. Numbers in parentheses are reference numbers where there is a published reference for the solution. While not all the solutions have been fully evaluated as to their efficacy, they can help reduce the risk factors which are present and hold promise as interventions. More efficacy studies are certainly needed in this area.

Appendix B - Solutions for Ergonomic Problems in New Construction

Heavy Equipment Operator Vibration	Better seat design (5,6)
Shovelling	Better handle design (7-10)
Laying Masonry Blocks	Adjustable scaffolds (14) Keep brick stack at proper height (12) Pump mortar to point of application (14) Limit weight of blocks (15,16) Redesign blocks with hand holds (16)
Carrying buckets of cement	Better handle design (17)
Formwork	Adjustable height saw horses Bent handle hammer design (19) New forms which are easier to dismantle Use of smaller form components
Crane Operation	Enclosed cabs, Better seat design
Concrete Floor Work	Tool for tying rods from standing height (29,30) Straight edge handle (34) Welded fabric nets (31,32)
Chipping Hammer Vibration	Vibration/noise dampened equipment (39) Lighter weight models
Spraying Fireproofing	Attachment of sprayer to belt for support
Installation of Ductwork	Use of hoist to crank ductwork to proper height
Plumbing installation	Install on side wall rather than overhead in Utility tunnels(42)
Electrical work - Screwdriving	Better design handles (45) Use of powered screwdrivers (44,46) Use of TORX head screws (44,46) Micropauses during continuous work (60)
Drywall Installation	Use of drill stand or bolt gun waist belt for overhead work (41,47,48) Use of dollies, carts to transport boards (54) Use of narrower boards (90 cm) (57,58) Use of handles, proper training (59) Use of swivel head screw guns (51) Plasterboard lifts (47,54)
Elevator Construction	Use of dollies, carts, lifting hooks and better planning (49)
Roofing	Use of cranes, dollies, smaller tubes of asphalt, better bucket handles (51) Use of asphalt tanker rather than kettle (50) New tool for fastening roof from standing height (52)
Building Exterior	Use of motorized scaffold, Sheet clad storage device (53) Mechanical window installation device (54)
Scaffold Erection	Use of hoists, newer scaffolds which are easier to carry and assemble (56)

APPENDIX 6

Agendas for WMD professional presentations during Year
One

AFL-CIO HEALTH & SAFETY CONFERENCE WORKSHOP:

RECOGNIZING AND CONTROLLING SAFETY & HEALTH HAZARDS IN CONSTRUCTION

- I. Introduction - Knut Ringen, CPWR - 5 mins.
CPWR Projects/Origins/Purpose/Sub-grantees
 - II. Recognizing hazards in construction
 - A. DISCUSSION: What are the hazards of construction?
Participants will identify the top 3 hazards associated with construction. Responses will be recorded on large flip chart and used as focus of discussion on risk perception in construction. Knut Ringen, CPWR -15 mins
 - B. Health Hazards Identified on a New Construction Project
 1. Noise/Ergonomics - Scott Schneider, OHF - 15 mins
 2. Chemical exposures - Pam Susie, OHF- 15 mins
 - overview
 - MMMF
 - Asphalt fumes
 - welding fumes (iron/manganese/zinc/lead)
 - dusts (gypsum, concrete, silica)
 - C. Health Hazards of Major Observed Exposures - Dr. Laura Welch, GWU - 20 mins
 1. MMMF
 2. Asphalt fumes
 3. Welding fumes
 4. Construction related dusts
 - II. Silica - Dennis Groce, NIOSH (20 mins)
- BREAK**
- III. Bridge/Building Renovation & Demolition - Mark Goldberg, Mt. Sinai - 15 mins
 - V. Health & Safety Hazard Controls
 - A. DISCUSSION - Unique aspects of hazard control on construction sites - 10 mins
 - B. Fall Protection - Steve Cooper, International Association of Bridge, Structural and Ornamental Ironworkers - 15 mins
 - C. Critical Path Mgmt. - Ernie Jorgensen, PSC - 15 mins.
 - VI. DISCUSSION/CLOSE: Reevaluation of participant's perception of principle hazards on a construction site. Knut Ringen, CPWR

*(Special thanks to the Center to Protect Workers' Rights and Pam Susie
of the Occupational Health Foundation for making arrangements for this workshop.)*

AGENDA

"SAFETY & HEALTH FINDINGS ON A NEW CONSTRUCTION PROJECT" OCTOBER 15, 1992

MACHINIST'S UNION BUILDING (AUDITORIUM)
9000 MACHINIST PLACE
UPPER MARLBORO, MARYLAND

9:00 - 9:30 am

WELCOME

George J. Kourpias, President
International Association of Machinists and Aerospace Workers

Stan Manvell, Vice President of Safety
James G. Davis Construction Company

INTRODUCTION

Pete Stafford, Senior Project Coordinator
Center to Protect Workers' Rights

Richard Stickle, President
National Capital Chapter of the American Society of Safety Engineers

Scott McMullen, President
Washington Metropolitan Area Construction Safety Association

PROGRAM OVERVIEW

Laura Welch, M.D.
George Washington University, Division of Occupational & Environmental Medicine

Participants in the construction research project from George Washington University Division of Occupational & Environmental Medicine and the Occupational Health Foundation will present health effects and control issues in specific topic areas of importance.

Laura Welch, M.D.
GWU Division of Occupational
& Environmental Medicine

Scott Schneider, CIH
Pam Susie
Occupational Health Foundation

Ernie Jorgensen, PE
Professional Safety Consultants

9:30 - 10:15 am	.....	Welding
10:15 - 10:30 am	.....	Break
10:30 - 11:15 am	.....	Synthetic Mineral Fibers (Fiberglass)
11:15 - 12:00 noon	.....	Asphalt
12:00 - 1:00 pm	.....	Lunch
1:00 - 1:30 pm	.....	Noise
1:30 - 2:00 pm	.....	Ergonomics
2:00 - 2:30 pm	.....	Critical Path Management/ Safety & Health
2:30 - 3:00 pm	.....	Questions & Answers
3:00 pm	.....	Adjourn



**FOR HEALTHY
COMMUNITIES**

Official Program of the

120th Annual Meeting

and Exhibition

November 8-12, 1992

Washington, DC

1102 *Omni Shoreham, Palladian*
Contemporary Issues in Breastfeeding

Presiders: *Jan Weingrad Smith, C.N.M., MS, MPH; Mitda Lazarov, MS, RD*

- 2:00 Introduction
- 2:10 Integrating Support for Breastfeeding into the Health Care of Women: Guidance from New Institute of Medicine Publications—*Linda A. Randolpb, MD, MPH; Carol W. Saitor, DSc*
- 2:25 Second Follow-up Report: The Surgeon General's Workshop on Breastfeeding and Human Lactation—*Sbelley Spitsak, MHS; Susan Shapiro Gross, MPH, RD; Carolyn Sbarbaugh, MS, RD; M. Elizabeth Brannon, MS, RD*
- 2:40 Maternal Attitude and Prenatal Participation in WIC as Predictors of Feeding Choice in a Group of Low-Income Women—*M. Kay Libbus, RN, DrPH; Linda Kolostor, RN*
- 2:55 Breastfeeding Promotion Using Incentives in WIC—*Joy Nwuke, BS; Theodore R. Parrish, DrPH; Doren Fredrickson, MD*
- 3:10 Curiosity as a Motive for Breastfeeding Initiation: Results from Ethnographic Research for a WIC-Centered Breastfeeding Promotion Project in Baltimore, Maryland—*Joan L. Russ, MPH; Margaret E. Bentley, PhD; Yvonne L. Bronner, ScD; Laura E. Caulfield, PhD; David M. Paige, MD*
- 3:25 Desired Qualities of a Breastfeeding Peer Counselor: Results from Ethnographic Research for a WIC-Centered Breastfeeding Promotion Project in Baltimore, Maryland—*Joan L. Russ, MPH; Margaret E. Bentley, PhD; Yvonne L. Bronner, ScD; Laura E. Caulfield, PhD; David M. Paige, MD*
- 3:40 Infant Feeding Method Choice in a WIC Population in Hawaii: Implications for Breastfeeding Promotion Programs—*Rachel Novotny, PhD; Edith C. Kieffer, PhD; Joanne Mor, MS; Maureen Thiele, MPH; Melissa Nikaido, MPH*
- 3:55 Strategies for the Development of Breastfeeding Policies to Promote Child Spacing—*Kristen A. Cooney, MA*
- 4:10 Discussion

Sponsors: Maternal and Child Health, Population and Family Planning, Food and Nutrition

1103 *Omni Shoreham, Governor's*
Research Topics in Maternal and Child Health

Part I: Public Health and Genetics

Presiders: *Andrew Chen; Jane Lin-Fu*

- 2:00 Introduction
- 2:05 Human Genetics Education Program: A Model for Preventing Birth Defects—*Raymond Kessel, PhD; James Stewart, PhD; Louise Elbaum, MSSW; Ruth Owens, MEd; Allison Fasbking, BA; Michael Patrick, PhD*
- 2:20 Access to Comprehensive Genetic Services: The Continued Challenge for Public Health Programs—*Jenny Miller, RN, MS, MPH*
- 2:35 Improving Prenatal Genetic Services for Latino/Puerto Rican Families Using "Soap Opera" Education Videotapes—*Evelyn Gonzalez, MS; Robert Greenstein, MD*
- 2:50 Insurance Implications of Molecular Diagnostic Technologies Derived from Human Genome Initiative Sponsored Research—*Lee A. Crandall, PhD*

3:05 Discussion

Part II: Open Discussion on the Human Genome: What about Genetic Services?

Sponsors: Maternal and Child Health, Forum on Bioethics

1104 *Capital Hilton, New York*
AOEC Clinical Case Studies in Occupational Medicine

Presider: *Raymond Demers, MD*

- 2:00 Occupational Asthma—*Kenneth Rosenman, MD*
- 2:30 Occupational Cancer—*Stephen Hessel, MD*
- 3:00 Lead Poisoning—*Rosemary Sokas, MD*
- 3:30 Solvent Encephalopathy—*Geralynn Kabn, MD*
- 4:00 Discussion

Sponsors: Occupational Health and Safety, Environment

1105 *Capital Hilton, Massachusetts*
Construction and Environmental Worker Health and Safety

Presider: *Sandy Tillet, MS*

- 2:00 An International Perspective: Occupational Safety and Health Programs in Construction—*Knut Ringen, DrPH; Anders Englund, MD; Gordon Atherley, MD*
- 2:20 Twenty Years of Follow-Up of Mortality and Cancer Incidence in Swedish Construction Workers—*Goran Engholm, PhD; Anders Englund, MD; David Michaels, PhD; Knut Ringen, DrPH;*
- 2:40 Cancer among Illinois Construction Workers—*Jane E. Keller, PhD; Holly L. Howe, PhD*
- 3:00 Medical Surveillance of Hazardous Waste Workers—*Brenda A. Cuccherini, PhD; Laura S. Welch, MD*
- 3:20 Construction Health Hazards—Construction Noise: Results of a Study on a New Construction Site—*Scott P. Schneider, MSIH; Pam Susie, MSIH*
- 3:40 Construction Health Hazards: Chemical Hazards on a New Construction Site—*Pam Susie, MSIH; Scott P. Schneider, MSIH*
- 4:00 Construction Health Hazards—Ergonomics Investigations on a New Construction Site—*Scott P. Schneider, MSIH; Pam Susie, MSIH*
- 4:20 Discussion

Sponsors: Occupational Health and Safety, Environment, Injury Control and Emergency Health Services

1106 *Capital Hilton, South American B*
Occupational Health in Developing Countries

Presiders: *Barry Levy, MD; Rob McConnell, MD*

- 2:00 Occupational Health Teaching and Research in Latin America—*Oscar Feo, MD*
- 2:20 Occupational Health in Nicaragua—*Allan Hrusk, PhD; Marianala Corriols, MD*
- 3:00 Migrant Farm Worker Safety and Health in the United States—*Mark Lyons, MPH*
- 3:20 Occupational Health in Cuba—*Miriam Martinez, MD; Pedro Almirall, MD*
- 3:40 Participatory Methods in Occupational Health and Safety Training—*Ellen Konor, MPH*

ACCESS TO COMPREHENSIVE GENETIC SERVICES: THE CONTINUED CHALLENGE FOR PUBLIC HEALTH PROGRAMS
Jenny Miller

Since the beginning of state genetic service programs, a main objective has been universal access to services. While the demand for state genetic services continues to grow, not all families who may benefit from genetic services are actually receiving them.

Great challenges exist for state genetic service programs to provide access to comprehensive services. First, changing sources of funding have created struggles over scarce resources between traditional public health programs, such as prenatal and child health programs, and genetic programs. Second, new services, such as maternal serum alpha-fetoprotein screening, have been added to some state programs. Third, with the technological advances occurring in genetics, particularly with the Human Genome Project, more sophisticated services are likely to be available in the near future.

This paper will address the challenges of providing access to comprehensive services and of raising the priority for genetic services among public health programs.

Scott P. Schneider, MSIH
Pam Susie, MSIH

**CONSTRUCTION HEALTH HAZARDS-
ERGONOMIC INVESTIGATIONS ON A NEW CONSTRUCTION SITE**

Ergonomic injuries are becoming more common in the US. They are attracting increased attention by the press and by the health and safety community. They represent a large portion of workers compensation costs, which are growing rapidly. In construction, this is also the case, yet construction ergonomics has received little attention. This investigation at a new construction site outside of Washington, D.C. looked at ergonomic problems of several trades, e.g., ironworkers, concrete finishers, masons. Several solutions will be recommended, including new ergonomically designed tools.

IMPROVING PRENATAL GENETIC SERVICES FOR LATINO/PUERTO RICAN FAMILIES USING "SOAP OPERA" EDUCATIONAL VIDEOTAPES. Evelyn Gonzalez, M.S. and Robert M. Greenstein, M.D. Our 1989 needs assessment found that in Hartford, CT., 38% of its population is of Latino origin, of which 95% is Puerto Rican. The assessment concluded that a lack of bilingual/bicultural personnel and educational materials contributed in part to the underutilization of prenatal genetic services. A further study by our Division in 1991 using multiple focus groups revealed that television is one of the most important sources for health information in the Latino community. Soap operas were watched by over 50% of focus group participants. We have produced and will present two Spanish language videotapes that address prenatal genetics issues for the Latino/Puerto Rican community. Each seven minute video is culturally and educationally appropriate and uses a soap opera format for dramatic emphasis. Puerto Rican writers and actors participated using a photo-novella design- consecutive still photos with Spanish dialogue voice over. The topics include (1) having a triple screen for birth defects and the results; and (2) experiencing genetic risk screening as part of a routine prenatal visit. The tapes will be evaluated at nine MCH prenatal clinics in Hartford in an effort to increase utilization and improve access to prenatal genetics services. Funded in part by an NCH SPRANS grant and by the CT. National Foundation-March of Dimes.

Scott P. Schneider, MSIH
Pam Susie, MSIH

**CONSTRUCTION HEALTH HAZARDS-
CONSTRUCTION NOISE: RESULTS OF A STUDY ON A NEW CONSTRUCTION SITE**

Construction noise has long been recognized as a health hazard for workers. Hearing loss among construction workers is rampant. Yet little research has been done on identifying sources of construction noise and control strategies. A recent investigation was made on a new construction site outside of Washington, D.C. The results of this study will be reviewed, identifying the primary sources of noise of the site, the magnitude of their contribution, the relative risks of the various trades, and possible control strategies. The use of hearing protection will also be discussed.

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Raymond Demers, MD, MPH
Kenneth Rosenman, MD
Stephen Hessel, MD
Rosemary Sokas, MD, MOH
Geralynn Kahn, MD, MPH

Chair
Occupational Asthma
Occupational Cancer
Lead Poisoning
Solvent Encephalopathy

Association of Occupational and Environmental Clinics (AOEC)

AOEC CLINICAL CASE STUDIES IN OCCUPATIONAL MEDICINE

In the development of disease from occupational exposures there are often diagnostic and treatment dilemmas. Four clinical case presentations explore the issues of work-related exposures, the disease process, preventive measures for others exposed, and ethical issues arising from intervention.

Pam Susie, MSIH
Scott P. Schneider, MSIH

**CONSTRUCTION HEALTH HAZARDS-
CHEMICAL HAZARDS ON A NEW CONSTRUCTION SITE**

In construction, safety hazards have always been the predominant concern, because injury and fatality rates are so high in this industry. But recently health hazards in construction have demanded more attention. The epidemic of asbestos disease in construction workers demonstrated that chemical hazards can and do affect construction workers. While asbestos is no longer used in buildings, construction uses a wide variety of chemicals. An investigation was made of chemical hazards during the construction of a new office building outside of Washington, D.C. Chemical use was followed from start to finish at the site. Major exposures, such as mineral wool, asphalt fumes and welding fumes, were documented with industrial hygiene sampling. Real-time monitoring was done to identify peak exposures. This presentation will review the major findings of this pilot study of chemical hazards on a new construction site. Conclusions will be made regarding the need for future research and how to control exposures in this industry.

1105

CANCER AMONG ILLINOIS CONSTRUCTION WORKERS

Keller, JF and Howe, HL

A series of case-control studies using subjects from the Illinois State Cancer Registry has been conducted. Logistic regression was used to control for age and history of tobacco and alcohol use. Construction workers were consistently found to be younger than other subjects and to have used alcohol and tobacco more often. Significant ($p < 0.05$) positive associations between cancer of the stomach and welding (Odds Ratio = 2.11, 95 percent CI = 1.09, 4.09), lung cancer and employment in the construction industry (Odds Ratio = 1.18, 95 percent CI = 1.02-1.26), and lung cancer and welding (Odds Ratio = 1.68, 95 percent CI = 1.03, 2.76) were found. Significant negative associations between cancer of the colon and welding (Odds Ratio = .54, 95 percent CI = .29, 1.00), cancer of the prostate and employment in the construction industry (Odds ratio = .76, 95 percent CI = .65 --.89), cancer of the prostate and plumbing (odds ratio = .44, 95 percent CI = .38 -- .50), cancer of the prostate and metal working (Odds Ratio = .43, 95 percent CI = .19 -- .93, and bladder cancer and employment as an electrician (Odds Ratio = .60, 95 percent CI = .36, 1.00) were found.

AN INTERNATIONAL PERSPECTIVE ON THE ORGANIZATION OF OCCUPATIONAL SAFETY AND HEALTH PROGRAMS IN THE CONSTRUCTION SECTOR.

Knut Ringen, Dr.P.H., Anders Englund, M.D., Gordon Atherley, M.D., Laborers' Health and Safety Fund of North America.

This presentation gives an overview of common themes in the organization of safety and health programs in the construction sector based on observations in Germany, Sweden, Holland, and Ontario, Canada. The nature of construction involves multi-employer arrangements, temporary and constantly changing work sites, and intermittent employment. These characteristics have led to similar approaches to the organization of safety and health programs, which by necessity are quite different from other economic sectors. We discuss common themes in the following areas: the role of government supervision and enforcement; joint union-employer governance; integrated programs of worksite prevention, medical monitoring and rehabilitation; data collection and epidemiological evaluation; and sources of funding. The United States is far behind other nations in construction safety and health, and these international perspective can be important lessons.

Baltimore, MD; Roundtable Monitor: R. Moure-Eraso, Ph.D., Mass-Lowell Work Environment, Lowell, MA; A. Taylor, Dr.P.H., UAW Health & Safety Dept., Detroit, MI.

All areas of occupational and environmental health are being affected by international free trade agreements. The 1989 U.S.—Canada Free Trade Agreement is currently in effect and the concept of "harmonizing" environmental standards have weakened more stringent Canadian regulations on chemical use and controls. The establishment of a North American Free Trade Agreement (NAFTA) negotiated between the United States, Mexico and Canada, awaiting congressional approval, makes the issue of "harmonization" of regulations between the three countries a vital regulatory issue. Occupational Health Standards harmonization would have important impacts in the practice of industrial hygiene. The NAFTA treaty requires risk assessment and cost benefit analysis as a basis for harmonization. Proponents and opponents of NAFTA from the United States, Canada and Mexico will address the AIHA Roundtable describing the experiences and plans for future occupational health standards applicable in the three countries.

The Impact of NAFTA on Canada's Workplaces and Communities. L. Ritchie, Confederation of Canadian Unions, Toronto, Canada.

The Impact of NAFTA on Mexico's Workplaces and Communities. A. Velasquez, Independent Textile Union, Irapueto, Mexico.

The Economics of the Environmental and Occupational Impact of NAFTA. T. Lee, Economic Policy Institute, Washington, DC.

Poster Session 3

1:00 p.m.—5:00 p.m.

C B2-1

Displayed

1:00 p.m.—5:00 p.m.

Attended

1:00 p.m.—3:00 p.m.

Session Arrangers: J.H. Jones, R.W. Hartle, NIOSH, Cincinnati, OH.

Biological Monitoring Papers 452–456

A Study on the Urinary Metabolites of Carbonyl Disulfide in Rats. (452) J.H. Roh, Y.H. Moon, Yonsei University College of Medicine, Seoul, Korea; C.N. Kim, Y.B. Cho, Yonsei University College of Health Science, Wonju, Korea.

The Workstation Checklist: An Essential Tool for the Toxicological Studies of Dose-Effect Relationships in Workers. (453) G. Truchon, D. Drolet, F. Desjardins, IRSST, Montreal, Quebec, Canada.

Biological Monitoring of the Occupational Exposure to Inhalation Anaesthetics in Operating Room Personnel. (454) M. Imbriani, S. Ghittori, IRCCS, Pavia, Italy.

Biological Monitoring of Pest Control Applicators. (455) D.B. Gibbons, R. Rutz, H.R. Fong, J.H. Ross, California Environmental Protection Agency, Sacramento, CA.

Breath Analysis of Volatile Hydrocarbons by Direct Sampling on Thermal Desorption. (456) G. Ljungkvist, R. Nordlinder, Department of Occupational Medicine, Sweden.

Bloodborne Pathogens Papers 457–460

An Estimate of the Nature, Frequency, and Circumstances of Percutaneous Injuries in a Dental Setting of the Indian Health Service (IHS): An Observational Pilot Study. (457) C.A. Hudson, C.J. Summers, S.L. Gravelle, R.J.

Davis, National Institute for Occupational Safety and Health, Atlanta, GA.

A Case Study of Hepatitis B, Potentially Contracted Through Exposure to Waste Water. (458) M.L. vanMeter, H.N. Smith, Los Alamos National Laboratory, Los Alamos, NM.

Reporting Barriers Associated with Needlestick Injuries to Hospital Employees. (459) L.A. Shands, R.E. Turner, USPHS-Navajo Area Indian Health Service, Window Rock, AZ; G.E. Savage, USPHS-National Institute for Occupational Safety & Health, Morgantown, WV.

The Penetration of Bloodborne Pathogens Through Protective Clothing. (460) J.E. Pasini, Aetna Life & Casualty, Hartford, CT.

Computer Applications Papers 461–467

Streamlining Chemical Inventory Reporting Under the Superfund Amendments & Reauthorization Act (SARA) Title III to Federal, State, and Local Agencies. (461) S.J. Bosso, L.L. Leslie, Chevron Corporation, San Francisco, CA.

An Interactive Computer Program for MSDS Training for Workers. (462) E. Marroquin, J. Sikes, C. Vanover, University of Alabama, Tuscaloosa, AL.

Sample Management, Analytical Processing and Data Reporting Integrated Within An Industrial Hygiene Laboratory. (463) J.W. Koehn, M.A. Altamira, Shell Development Company, Houston, TN.

Restructuring of a Laboratory Information Management System (LIMS) in an Industrial Hygiene Laboratory. (464) P. Lariviere, A. Laioie, T. Petitjean-Roget, G. Bessimon, IRSST, Montreal, Quebec, Canada.

Development of a Physical Site Oriented Job Classification Coding System for Computer Databases to Facilitate Accurate and Dependable Industrial Hygiene Exposure to Tracking. (465) J.G. Zvetan, A.E. Carlson, M.A. Companik, B.J. Furino, W.W. Walker, Amoco Corporation, Chicago, IL.

Development and Application of an Information System for Air-Borne Chemical Sampling Methods. (466) C. Bahler, J. Brown, S. Hazard, B. Peters, Supelco, Inc., Bellefonte, PA.

Air Sampling Methods Database. (467) M. Morganti, L. Chaney, E. Chen, Roy F. Weston, Inc./REAC, Edison, NJ; T. Pritchett, US Environmental Protection Agency, Edison, NJ.

Ergonomics Papers 468–478

The Recording of Observed Physical Exposures (ROPEM): A Simple and Low-Cost Method of Analyzing Upper Extremity Ergonomic Stressors. (468) G.M. Perez-Balke, University of Massachusetts, Somerville, MA.

Upper Extremity Exposures to Ergonomic Stressors on a Candy Traying, Straightening and Packaging Line. (469) G.M. Perez-Balke, U.S. Department of Labor, OSHA, Boston, MA; R. Kowalski, U.S. Department of Labor, Bridgeport, CT.

An Ergonomics Approach for the Prevention of Carpal Tunnel Syndrome. (470) M.E. Danz-Reece, Exxon Biomedical Sciences, Inc., East Millstone, NJ; L. Booher, Exxon Company USA, Baton Rouge, LA.

An Ergonomic Solution to High Health Risk Workstations. (471) P.E. Miceli, T.J. Macias, Northern Telecom, Inc., San Diego, CA.

A Challenge: Implementing & Maintaining an Effective Ergonomics Program with Limited Resources. (472) W.G. Rostykus, Hewlett Packard, Everett, WA.

A Diverse Perspective on the Process Used to Implement Ergonomic Programs at a Chemical Manufacturing Company. (473) D.K. Martin, E.A. Lackey, The Dow Chemical Company, Midland, MI; M.E. Phillips, The Dow Company, Freeport, TX.

Effect of Roof Inclination on Postural Stability and Perceived Sense of Fall. (474) R. Emerich, Rochester, NY; A. Bhattacharya, P.A. Succop, A. Bagchee, University of Cincinnati, Cincinnati, OH.

A Method to Maximize the Effect of Limited Resources to Reduce the Risk of VDT-Related Musculoskeletal Stress at Sites with 1000's of VDT Workstations. (476) M.P. Hubbell, McDonnell Douglas Space Systems Company, Huntington Beach, CA.

An Ergonomic Study of VDT Workstations in Office. (477) C. Lu, Louisiana State University, Baton Rouge, LA; J. Caylor, Freeport McMoran, Inc., New Orleans, LA; F. Aghazadeh, Louisiana State University, Baton Rouge, LA.

Ergonomics and Construction: A Review of Potential Hazards in New Construction. (478) S.P. Schneider, P. Susie, Occupational Health Foundation, Washington, DC.

Indoor Air Quality Papers 479–487

Carbon Monoxide Levels in Smoking and Non-Smoking Establishment Casinos. (479) J.D. Paz, L. Walker, J & L, Inc., Las Vegas, NV.

Air Quality and Comfort Parameters Within Complaint-Free Office Environments. (481) K.E. Kuppinger, K.D. Blehm, Colorado State University, Fort Collins, CO.

An Indoor Air Quality Investigation of a Large Office Complex. (481) K.A. Kamps, Los Alamos National Laboratory, Los Alamos, NM.

Using the "Art" of Industrial Hygiene to Identify the Cause of Illness Associated with an Odor in an Office Building. (482) J.M. Villnave, Hazcon, Inc., Portland, OR.

Microbiological Characterization of an Insulated Heating, Ventilation, and Air Conditioning (HVAC) Duct System Twenty Years of Age. (483) S.A. Prosch, Mankato State University, Mankato, MN; G.E. Caple, Minnesota Department of Employee Relations, St. Paul, MN.

Occupant Complaint Resolution in an Office Building Complex: Part I. Application of Questionnaire Feedback to Assist Determining Environmental Sampling Strategy. (484) W.T. Chan, X. Chen, K.A. Schwartz, Uniformed Services University of the Health Sciences, Rockville, MD; V. Avitto, US Public Health Service, Rockville, MD.

Indoor Air Quality in a Newly Renovated Building. (485) S.W. Rhodes, H.G. Jiang, E.B. Sansone, NCI-FCRDC, PRI/DynCorp, Frederick, MD.

Office Building Indoor Hazards Evaluation After the Chicago Flood. (486) R.G. Kerzee, L. Cocchiarella, L.M. Conroy, R. Hershow, D. Hryhorczuk, University of Illinois, Chicago, IL; W.N. Burton, Northwestern University Medical School, Chicago, IL.

Occupant Complaint Resolution in an Office Building Complex: Part II. Assessment of Total Suspended Particulates for Polycyclic Aromatic Hydrocarbons. (487) W.T. Chan, K.A. Schwartz, Uniformed Services University of the Health Sciences, Rockville, MD; J.C. Chuang, Atmospheric Science and Technology, Columbus, OH.

Up With Life). Safety, Purchasing, plant management and employees. Lead by a core steering committee, a system was developed to implement an effective ergonomic program for over 7000 employees in various operating units throughout the division. Subcommittees within this group assume responsibility for team communications, new application of tools, computer use and engineering development.

Continuing efforts will be focused on employee education and awareness. Increasing the understanding of basic body mechanics, monitoring workplace incidence and implementing simple workplace modifications will help to minimize the number of injuries and reduce costs associated with ergonomic injuries.

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EFFECT OF ROOF INCLINATION ON POSTURAL STABILITY AND PERCEIVED SENSE OF FALL R. Emerich, 24 Sesqui Drive, Rochester, NY 14624; A. Bhattacharya, P.A. Succop and A. Bagchee, Department of Environmental Health, University of Cincinnati Medical School, Cincinnati, OH 45267-0056.

The objective of this study was to develop a method of measuring postural sway on a sloped surface using a strain-gauge force platform and correlating the postural sway of the task being performed with the slope of the surface, the perceived risk (PR) of falling, and body sway. The sloped surface was used to simulate the roof surface. The force platform was used to measure the postural stability of the individual by measuring the amount of area (SA) traversed by the movement of the individual's center of pressure (CP). Various tasks were performed by fifteen subjects on both sloped surfaces and flat surfaces to simulate work tasks within the roofing construction and repair industry. For this study, slopes of 0°, 14° and 26° were chosen. The tasks were based on video data collected at a roofing site and motions commonly performed in the roofing industry. Tasks selected were forward lifts facing both up and down the slope, side-to-side lifts facing both up and down the slope, and standing erect and motionless. A questionnaire was developed to examine the correlation between perceived risk of fall and body sway and postural sway as measured by the force platform. The perceived risk was rated on a scale of zero to five. Zero was defined as no perceived risk and five as the riskiest. SA ranged from 0.8 cm² to 79.3 cm². A larger SA implied poorer balance. The average SA was 26.4 cm² and PR was 1.0. As the roof angle increased, the SA increased. PR showed a poor correlation with SA (r = 0.23, p < .05), implying that the subjects may not realize that they are near their Stability Boundary (SB) and may be in greater danger of falling. Repeated measures analysis of variance was used to study task effects, incline effects, and the interaction of tasks and inclines. All effects were significant (p < .0001). As the slope of the surface increased, so did proximity to SB. This also depended on the task. When standing still, both the SA and proximity to SB were worse for facing down the slope than facing up. For the side-to-side lifting task, the proximity to SB was closest and SA was highest. The forward reaching task showed that the subject's CP was closest to their SB facing up the slope, but that the SA was largest when facing down the slope. These results indicate that worker stability is dependent on the surface slope on which they stand and the task being performed. It is not true that the worker will always be able to sense when they are at an increased risk of falling.

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A METHOD TO MAXIMIZE THE EFFECT OF LIMITED RESOURCES TO REDUCE THE RISK OF VDT-RELATED MUSCULOSKELETAL STRESS AT SITES WITH 1000'S OF VDT WORKSTATIONS M.P. Hubbell, McDonnell Douglas Space Systems Co., 5301 Bolsa Ave., A3-316-12-1, Huntington Beach Ca., 92647.

A simple, computer-based, risk assessment survey method has been developed to identify and prioritize video display terminal (VDT) workstations with ergonomic deficiencies, to identify and prioritize all employees needing training on VDT ergonomic risk factors and proper workstation adjustment, and to identify those employees with current, significant discomfort and those employees with a history of previous wrist or hand surgery or treatment from any cause. By extraction of selected response data, workstations likely to pose significant risk and those VDT users at highest risk for injury or repeat-injury can be identified for initial allocation of resources.

This assessment tool incorporates the basic steps in the evaluation for potential ergonomic risk areas as seen in current proposed Cal/OSHA regulation. It also provides a method for employers to project budget needs for a multi-phased workstation upgrade program. The survey incorporates 12 questions and response time is about 3 min. per employee. Each Dept. clerk inputs her group's data so survey manager receives only completed diskette. Results of this survey have verified the reported high incidence of musculoskeletal discomfort found among VDT users and demonstrates the correlation of discomfort with poor workstation arrangement and with average daily hours at the VDT.

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AN ERGONOMIC STUDY OF VDT WORKSTATIONS IN OFFICE H. Lu, Department of Industrial and Manufacturing Systems Engineering, Louisiana State University, Baton Rouge, LA 70803; J. Caylor, Corporate Safety & Industrial Health Department, Freeport McMoran Inc., New Orleans, LA 70112; F. Aghazadeh, Department of Industrial and Manufacturing Systems Engineering, Louisiana State University, Baton Rouge, LA.

In order to determine the extent of musculoskeletal illnesses among workers at VDT workstations and to prevent health problems, an ergonomic study of workstations was conducted among 190 clerical employees. A survey was designed with the intent of collecting information on users' background, health state, VDT tasks, VDT workstations, and work environment. Upon receipt of the completed questionnaires, observations, interviews and measurements at workplace were conducted. One hundred seventeen employees responded to the questionnaire; a response rate of 62 percent. The operators who participated in this survey were full time employees with an average working time of 8.2 hours per day, ranging from 7.75 to 10 hours per day. Ninety percent of clerical employees spent more than 4 hours per day working with VDTs. Types of VDT work included data entry, word processing, information retrieval, and telephone directory. The survey results indicate that thirty percent of operators experienced frequent or constant neck discomfort and headaches. Lower back pain, fatigue, and eye strain constituted the rest of complaints. On the other hand, the study revealed a lack of knowledge of workstation adjustment among the clerical workers. Interviews and observations at workplace showed that auxiliary workstation products such as the document holders, back rests, wrist rest, and anti-glare screens were effective in increasing the comfort and in reducing the symptoms at VDT workstations. It is concluded that the musculoskeletal disorders, visual symptoms, and stress among VDT operators can be reduced through better workstation design and training of VDT users. The training of VDT users on the basic ergonomics knowledge, workstation adjustment, the use of auxiliary products, and ways of working with VDTs is strongly recommended.

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ERGONOMICS AND CONSTRUCTION: A REVIEW OF POTENTIAL HAZARDS IN NEW CONSTRUCTION S.P. Schneider and P. Susie, Occupational Health Foundation, 1126 Sixteenth St., NW, Washington, DC, 20036.

Ergonomics is a growing field within occupational safety and health. Ergonomic hazards are those where the design of the work or workplace causes injury, e.g. musculoskeletal problems. Injury rates attributable to ergonomic hazards are skyrocketing, accounting for the majority of "occupational diseases" in the 1989 annual survey by the U.S. Bureau of Labor statistics. While interest and attention has been growing, most of the focus has been on industrial and office workers. Almost no research has been done in the U.S. on ergonomic problems of construction workers. This paper is a review of potential ergonomic hazards in construction work. It summarizes the findings from published literature reports as well as findings from a year-long investigation of health hazards on a new construction site in suburban Washington, D.C. The review is structured to follow the sequence of events in the construction of a new building. The review will also, simultaneously, refer to ergonomic solutions that exist, where they have been developed or devised. This review will only deal with the hazards of new construction. Renovation of existing structures, the segment of the work which is growing, is not discussed here. Many of the same problems and principles apply however.

Papers 479-487 Indoor Air Quality

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CARBON MONOXIDE LEVELS IN SMOKING AND NON-SMOKING ESTABLISHMENT CASINOS J.D. PAZ, and L. Walker, J & L, Inc., P.O. Box 33036, Las Vegas, Nevada 89133.

An indoor air quality survey was conducted of smoking and non-smoking gaming establishments. Surveys were performed because of recent newspaper articles which raised concerns about health effects of smoking on non-smokers and gaming employees.

Personal Short Term Exposure Levels (STEL) for carbon monoxide were conducted using a passive dosimeter, Model L, manufactured by Advance Optchemical Research, Inc. Area monitoring for CO, and O₂ were performed in taverns with gaming, using PHD Biosystem Monitor.

APPENDIX 7

Draft Script for Ergonomic Video

DRAFT SCRIPT FOR ERGONOMICS VIDEO-Sept 8,1993

BEGIN WITH INTERVIEW OF WORKERS WHO HAVE BEEN INJURED

Each explains how they injured their back, how it has affected their ability to work and their home life and how it could have been prevented.

Back injuries, shoulder problems, wrist and knee injuries. These are the most common injuries in the workplace and the most costly. Back injuries alone account for about one third of all workplace injuries and over half of all compensation costs. Not only are they costly to contractors, but they are destroying the lives and livelihood of thousands of construction workers each year.

IMAGES: FOOTAGE OF CONSTRUCTION WORKERS WORKING

What causes these injuries?

There are many well-known "risk factors" which can make a job dangerous to your back, knees, or wrist.

First is awkward postures. Working with your arms overhead all day or picking up material from floor level is known to be hazardous. And construction work, by definition, requires a lot of work at floor or ceiling level. Finish work on ceilings or floor is a good example. Roof work and concrete floor work also require a constant bent over posture.

IMAGES: SHOW FOOTAGE OF CONSTRUCTION WORKERS IN AWKWARD POSTURES, REACHING, LIFTING, LOWERING, MOVING MATERIAL- ROOF WORK, CONCRETE WORK

Second, the amount of force required for a job can make it dangerous. Construction work requires a lot of lifting and moving of heavy materials. Masons, for example, must lift heavy blocks all day long and suffer from a lot of back problems. While some workers can lift or carry very heavy loads, other workers may not be as strong. Even a light load, if lifted in an awkward posture or many times a day, can be hazardous.

IMAGES: LAYING CONCRETE BLOCKS, LIFTING, CARRYING, STRONG MOVEMENTS, HEAVY LOADS

Third, repetitive jobs can be particularly dangerous. Fastening drywall or tying rebar, for example, requires constant repetitive motions. Carpet laying requires constant use of a knee kicker, which also places a lot of force on the knee.

IMAGES: FASTENING DRYWALL, TYING REBAR, CARPET LAYING USE OF KNEE KICKER

What can we do about it????

Some would argue that construction work is hard and these injuries are just part of the job. We don't believe that. Construction workers must work smarter not harder. New tools and work methods can be designed or used to reduce the risk of injury. New shovels exist which can reduce the amount of bending required. Machines have been designed for tying rebar from a standing height, like a giant staple gun. Masonry blocks have been designed to include handholds to make them easier to lift. We do not have to become disabled because of our work.

IMAGES: SHOW NEW TOOLS BEING USED, TYING REBAR, NEW CONCRETE BLOCKS, NEW SHOVELS, ELECTRIC BATTERY SCREWDRIVERS

Our task must be to identify those jobs which cause the most injuries and the risk factors that exist. You are the expert on your job and know what parts are the most difficult to do. Next ask ourselves, what, if anything, can be done to reduce the risk of injury? Everyone has good ideas on how to make their job better or easier. And then, how can we help make these changes?

IMAGES: WORKERS MEETING, TALKING OVER IDEAS FOR CHANGE

The Center to Protect Workers' Rights has begun a national effort to prevent musculoskeletal injuries among construction workers under a grant from the National Institute for Occupational Safety and Health (NIOSH). The CPWR has published a review of ergonomic hazards in construction which is available. We need your help in this effort. Please contact the CPWR if you would like to be part of this effort.

IMAGES: CPWR OFFICES OR LOGO OR CONFERENCE FOOTAGE

APPENDIX 8

Dissemination Plan for Iowa Center

Activity 1 -- International/National Construction Union Publications

- Step 1: With the assistance of CPWR, two to three national construction unions will be identified and selected on a pilot basis for the purposes of developing articles in their membership publications.
- Step 2: Based on information contained in the WMD database, brief, trade-specific summary articles will be developed and submitted to the unions for publications.
- Step 3: Articles will conclude with a telephone number and workers will be encouraged to call to obtain more information about WMD problems and solutions in their particular trade.
- Step 4: The number of telephone responses received by researchers at NHCRC based on these articles will serve two purposes: 1) to indicate the effectiveness of transmitting WMD information through union/worker publications; and 2) to provide researchers with the opportunity to ask workers directly how best to provide WMD information in the future.

If articles in the pilot unions generate a significant number of requests, the final dissemination strategy will expand this activity to all fifteen construction unions, and NHCRC will pursue the creation of a 1-800 number to disseminate information based on worker requests resulting from these articles.

Activity 2 -- National and Regional Construction Union Participation

- Step 1: NHCRC researchers will contact appropriate Building Trades Councils in Iowa with assistance from CPWR.
- Step 2: Council officials, representing local construction unions in a given geographical area, will identify appropriate union officials for contact by NHCRC. Union representatives to be contacted will include local union business managers/agents; apprenticeship training directors/instructors; and labor/management fund trustees.
- Step 3: As opposed to Activity 1, where NHCRC waits for worker requests, researchers will pro-actively contact identified local union officials in this step. Through the development of a short, standardized questionnaire, union officials will be asked directly how best to disseminate WMD information to the workers they represent.
- Step 4: While NHCRC solicits this information from local union officials at the regional level, CPWR will simultaneously solicit input from union safety and

health representatives at the national level. As part of its ongoing construction safety and health program, CPWR will meet with these officials monthly throughout YEAR 02.

Working directly with construction union officials at the national and regional level is particularly advantageous in the development of an overall industry information dissemination strategy. It is important to develop direct communication at both levels, as each will provide input that is necessary for an effective dissemination program targeting construction workers. National union leaders can best tell researchers how to get information into the hands of local unions; whereas local union leaders can in turn suggest how to further transmit the information on down to construction workers directly.

Activity 3 -- Worker Focus Group Meetings

Step 1: As part of the hazard identification and training component of this project, consortium members will conduct worker focus group meetings throughout YEAR 02 in Iowa, Washington, DC., and Boston, Mass. While these meetings will be conducted primarily for other purposes, e.g., worker input on hazardous tasks, NHCRC will take advantage of these opportunities to solicit information from workers regarding the information dissemination strategy.

Activity 4 -- Construction Employer Participation

Step 1: Similar to Activity 1, articles will be developed and published in contractors association publications. With CPWR assistance, NHCRC will work closely with two large construction employer associations; the National Erectors Association (NEA), and the National Constructors Association (NCA). Based on telephone requests as a result of these articles, NHCRC will be able to determine if they are effective in disseminating information to construction employers, and will also be given the opportunity to ask employers directly how best to provide WMD information to contractors.

Step 2: Employers are involved in all aspects and in every geographical region of the country where the CPWR WMD project is being carried out. Working with consortium members in each area where task forces and/or labor/management advisory groups have been established for this project, NHCRC will solicit information from employers through these forums and in conjunction with the other consortium members.

Step 3: CPWR, which meets regularly with contractor groups as part of its overall safety and health program, will solicit information regarding information dissemination directly as part of its ongoing activities.

Step 4: NHCRC will collect and review information resulting from Steps 1 through 3.

Activity 5 -- Development of Strategy

- Step 1: Based on the findings of the above activities, NHCRC will develop a detailed construction industry WMD information dissemination strategy in YEAR 02.
- Step 2: The plan will be disseminated to the CPWR consortium and to NIOSH for review and comment.
- Step 3: The plan will be revised based on comments resulting from Step 2.
- Step 4: The dissemination plan will be implemented.

APPENDIX 9

Impact Newsletter with Ergonomic Articles

IMPACT

ON CONSTRUCTION

SAFETY AND HEALTH

No. 2
Volume XI

September 1993



CONFERENCE SETS AGENDA FOR CONSTRUCTION SAFETY AND HEALTH

Leaders from labor, management, government, and science are working to advance an agenda for improved construction safety and health in the United States. The 10-part agenda grew out of the first *National Conference on Ergonomics, Safety, and Health in Construction* — held in Washington, D.C. July 18 to 22 and attended by more than 800 people.

The agenda's goals include a national labor-management organization, improved data sets, and new approaches to regulation. Conference sponsors included the Center to Protect Workers' Rights, the U.S. Department of Energy, the National Institute for Occupational Safety and Health (NIOSH), the U.S. Occupational Safety and Health Administration (OSHA), the National Constructors Association, and the National Erectors Association. Four labor-management organizations from Europe and Canada also were actively involved.



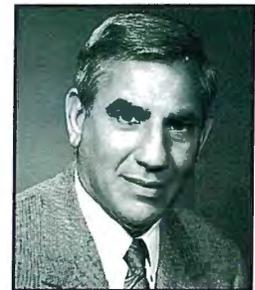
Keynote speakers defined the problem. J. Donald Millar, M.D., outgoing director of NIOSH and a grandson of two construction workers, declared the rate of deaths and injuries in construction "an epidemic."

Riley Bechtel, president and chief executive officer of the Bechtel Group, said "all accidents are preventable" and described Bechtel's current zero accidents program. (See **CONFERENCE**, page 5)

CPWR ANNOUNCES RESEARCH FUNDING FOR CONSTRUCTION SAFETY AND HEALTH

The Center to Protect Workers' Rights is providing funding for studies of ways to improve safety and health in construction. The money will support applied research projects in the United States lasting from a few days to two years.

"This is an opportunity to advance the state of the art substantially and save lives," said Robert A. Georgine, president of the Building and Construction Trades Department, AFL-CIO, and the Center to Protect Workers' Rights. "We have an appalling rate of deaths and injuries in construction in this country — partly because researchers haven't had enough financial support to study the problems. This money is a big step in the right direction." (See **FUNDING**, page 2)



Robert A. Georgine

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J. DONALD MILLAR RETIRES AS NIOSH DIRECTOR AFTER 12 YEARS

You may have heard

J. Donald Millar, M.D. speak at the July *National Conference on Ergonomics, Safety, and Health in Construction*. You may not have realized, however, that you were hearing Dr. Millar's last public address as director of the National Institute for Occupational Safety and Health (NIOSH). After 12 years of dedicated and visionary leadership, Dr. Millar retired on July 31, 1993.

It is significant and appropriate that Dr. Millar's final public presentation in his NIOSH post addressed the plight of the construction worker. Dr. Millar's family heritage is intertwined with the construction trade. And, one of his most enduring accomplishments as NIOSH director includes expanding research and services to workers who have fallen outside traditional occupational safety and health programs. Construction workers are a significant portion of this category, as are workers in agriculture and small business.

As director, Dr. Millar greatly expanded and furthered the mission of NIOSH by leading it to identify the 10 leading occupational diseases and injuries — and to propose a national prevention strategy for each one. Under Dr. Millar's directorship, NIOSH also spearheaded efforts to establish a surveillance system that, along with state and local health departments, collects data on selected occupational injuries and illnesses to target prevention strategies. In response to rising concern over workplace exposure to drug-resistant tuberculosis and the virus that causes AIDS, Dr. Millar initiated NIOSH research into infectious diseases in the workplace.

By focusing on hazards that would plague workers and occupational safety and health specialists alike in the



J. Donald Millar

1990s, Dr. Millar identified three "occupational epidemics": cumulative trauma disorders, indoor environmental problems, and stress. NIOSH intensified its efforts to address

these newly emerging workplace hazards.

In his final year as director, Dr. Millar began implementing Dr. W. Edward Deming's philosophy of total quality management (TQM) throughout NIOSH. The NIOSH quality initiative will focus on continuously improving the institute in order to more effectively protect working Americans and fulfill the NIOSH vision: "Delivering on the

Nation's Promise, Safety and Health at Work for all People...Through Prevention."

Dr. Millar's commitment to safe and healthful workplaces will continue as he enters the private sector. He will remain an invaluable asset to NIOSH and the nearly 130 million working Americans.

Dr. Millar's example of action and commitment to the occupational safety and health needs of this nation will continue under the direction of the acting NIOSH director, Richard A. Lemen, Ph.D. NIOSH is now selecting a new director who should be in place after the first of the year.

FUNDING from page 1

CPWR will fund two types of studies, beginning October 1:

- *Opportunistic studies will take advantage of unforeseen or hard-to-predict opportunities to investigate a safety or health problem. For example, if a construction worker on a project has suffered a disorder that usually is caused by a toxic exposure, an investigator might want to visit the site to sample chemical exposures and to examine a few other workers who seem to have similar problems. Such studies can take a few days or as long as two years. Maximum funding will be \$20,000.*

- *Pilot studies will more thoroughly define a problem and point up possible new solutions. So, for example, an investigator might evaluate a new method to prevent carpal tunnel syndrome among iron workers. Or, a researcher might evaluate the usefulness of a computer program in monitoring work-related illnesses. Pilot studies are expected to last for one or two years and will receive up to \$20,000. Some pilot studies may be expanded in time and size.*

Federal funding for construction research long lagged behind spending for research in mining and other industrial sectors. Federal funding for research on occupational safety and health in construction in 1988 totaled \$300,000, but has grown to \$7 million for 1993.

To obtain guidelines for potential applicants, call or write to the Research Projects Coordinator, CPWR, 111 Massachusetts Ave. NW., Washington, D.C. 20001, 202-962-8490/202-962-8499 (fax).

REGIONAL CONFERENCES PLANNED FOR 1994

The Center to Protect Workers' Rights (CPWR) is coordinating a series of four or five brief regional conferences for decisionmakers in the construction industry in 1994. The programs will cover safety, health, ergonomics, and labor-management issues raised at the *National Conference on Ergonomics, Safety, and Health in Construction* in Washington, D.C., in July 1993.

The national conference defined the state of art in construction safety and health and set a national agenda to reduce injuries and illnesses in construction.



The regional conferences will take the safe and healthful workplace message to the grassroots — to local union representatives, union members, and contractors. Each conference will run one and one-half days. The program will cover the latest knowledge about safety and health practices. Each regional conference will be tailored to meet the needs of the region. CPWR will work closely with local sponsors to develop each program.

"Contractors and local union members must be actively involved in creating safe workplaces. The knowledge and information from the national conference must reach the local level. For this reason we are taking our message on the road - directly to the members," said Robert A. Georgine, president of the BCTD and CPWR.

"Regional meetings are needed. We have a lot of work to do. The level of work-related accidents and illnesses among construction workers in the United States is much greater than in other industrialized countries," he continued.

Tentative conference locations are: Chicago, Las Vegas, Atlanta, Boston, and Seattle.

The four regional conference will be scheduled throughout 1994, specific dates are being coordinated with each region.

Each regional conference will feature a trade show of construction equipment and new technology. Often there are new tools or work methods that could be used to reduce injury rates. Some of these tools will be displayed at these conferences to give participants a chance to try them out. Some of the new innovative tools will be from Sweden.

Watch your mail for upcoming information on the regional conferences.

CONSTRUCTION BIBLIOGRAPHY AVAILABLE

For the first time, a bibliography lists writings from Canada, Europe, and the United States on work-related musculoskeletal disorders and construction work. The annotated listing of nearly 300 publications — most of them peer reviewed — focuses on the biomedical, industrial hygiene, and ergonomics literature.

The bibliography, available from the Center to Protect Workers' Rights (CPWR), should help researchers to focus better on the information available on ergonomics and construction injuries — and the lack of it in many areas.

"Although preliminary studies have been done on some trades and work tasks — for instance, bricklayers and crane operators — others have received no attention," said Robert A. Georgine, president of the Building and Construction Trades Department, AFL-CIO and CPWR. "There is a lot of room for research. We want to cut the epidemic of disabling injuries and improve our workers' quality of life."

Work-related musculoskeletal disorders are rampant among construction workers and are believed to be responsible for as much as two-thirds of workers' compensation costs. The rate of lost-time injuries - requiring time off to recover - and the average length of recovery time needed have been increasing for 15 years.

The bibliography was prepared by the Department of Preventive Medicine and Environmental Health, College of Medicine, University of Iowa. For a copy, write CPWR, 111 Massachusetts Avenue NW., Washington, D.C. 20001. There is a \$5 charge.

A TASK-BASED APPROACH TO MEASURING EXPOSURES ON THE JOB

Faced with dusts, fumes, and chemicals, construction workers have higher-than-average death rates for many diseases. For instance, studies by the National Institute for Occupational Safety and Health (NIOSH) have found that construction workers are more than three times as likely to die of asbestosis or silicosis as the general population.

But no one has shown which construction workers are most at risk. To answer this question, the Center to Protect Workers' Rights (CPWR) is trying a new approach to measuring hazards on the job. CPWR is developing a task-based exposure assessment model (T-BEAM) for construction. This project is part of a larger research initiative that brings representatives of the building trades together with safety and health professionals from government and universities.

Exposures to hazards on the job often are studied by attaching a sampling device to a worker to measure an 8-hour average exposure. In an assembly plant — where each worker does the same thing all day — this measurement may give a good idea of the hazards workers are exposed to over the long haul. But, on a construction site, the materials and tools used and the worker's location on the site change all the time. So, exposures can change from day to day — or even hour to hour.

What remains fairly constant in construction is the task for each trade. For instance, a pipefitter may weld carbon steel on one project one month and the next month weld stainless steel in a power plant. While the sites and metals change, the task remains the same. This is why the CPWR project will focus on tasks.

The T-BEAM project will:

- Identify tasks involving exposures to hazardous agents; "worker specialists" will help industrial hygienists identify hazardous tasks.



Iron worker being tested for metal fumes exposure

- Document tasks and important variables (such as process, materials, and tools) and measure exposures associated with those tasks.
- Set up a work group to devise engineering controls for health hazards in construction.

For more information on this project, contact Pam Susi, CPWR, 111 Massachusetts Ave, N.W., Washington, D.C. 20001, 202-962-8490.

EMERGENCY ROOM VISITS HELP INVESTIGATORS STUDY INJURIES

George Washington University (GWU) is looking to its hospital emergency room in order to learn more about construction worker injuries. Since November 1990, doctors in GWU's Division of Occupational and Environmental Medicine have reviewed the medical charts of all construction workers who have visited the emergency room with an injury or illness believed to be work-related. In the first two years, the project gathered information on 575 injured construction workers.

Carpenters, laborers, "construction workers," and electricians needed emergency care most often, but other trades were also seen. Injuries were most often caused by sharp objects (27%), falls (16%), and falling objects (12%). Almost one-third of the falls were from ladders. Thirty-five percent of injuries were to the hands, wrist, or fingers. The hand injuries included lacerations, contusions, abrasions, fractures, crushes, dislocations, and burns.

Project staff are looking for trade-specific injury patterns, so they can recommend prevention strategies.

(See *GWU*, page 5)

CONFERENCE from page 1

Robert A. Georgine, president of the Building and Construction Trades Department and conference chair, noted that "safety and health improvements mean economic improvements as well. This is a win-win proposition for workers and employers." He said more union-management cooperation will be needed to solve the safety and health problems.

Senator Tom Harkin (D-Iowa), just back from the floods that wracked much of his home state, said safety and health programs would be important for Iowa's rebuilding.

As many as 2,100 construction workers in the U.S. die each year of work-related injuries — eight per workday. The U.S. death rate is much higher than in other industrialized countries.

Prof. John Dunlop of Harvard University, conference rapporteur, presented 10 conference recommendations to a closing session. The recommendations were based on notes from more than 100 speakers and 15 workshop discussions.

Dunlop, chair of the U.S. Commission for the Future of Worker-Management Relations, said, first, there is an "urgent" need to establish a national organization to further safety and health. It should be started by unions and contractors engaged in collective bargaining.

The organization should draw on the best scientific data and recommend standards to OSHA, Dunlop said. He added that other management organizations and labor would need to be included in the organization later.

Dunlop also listed these goals:

2. Site-specific safety and health programs are needed. All projects above a given size need safety committees; the committees should have special training and be involved in project planning.
3. Vastly improved — and detailed — data sets are needed on work-related injuries and illnesses.
4. New approaches to regulation are needed — particularly negotiated rulemaking involving all interested parties.
5. Project-based efforts to improve workers' compensation should be encouraged. One example is a program in western Massachusetts. Also, the proposed national safety and health organization should help develop ways at the state level to change workers' comp procedures.
6. Health coverage under workers' comp should be combined with general health insurance. This is

partly because it is so hard to tell work-related problems from other health problems.

7. Joint union-management health and welfare programs mandated by Taft-Hartley should be used to improve worker health.
8. Joint labor-management training programs are key to improved safety and health in construction.
9. International linkages should be fostered, even though some programs from abroad won't work in the U.S.
10. More research is needed, including research on the economics of safety and health practices.

Georgine presented the conference agenda to the House Education and Labor Committee July 29. A conference report based on the recommendations will be presented to industry leaders, Congress, and federal agencies. It will also be sent to all conference participants.

GWU from page 4

The investigators have also begun telephoning construction workers several days after their injuries to collect more detailed information on injury circumstances, work practices, and worker training — and to hear the workers' ideas about possible preventive measures.

Emergency department records were a useful surveillance data source for the initial identification and description of work-related injuries. The records can also help to set priorities for prevention activities.

Support for this surveillance project is provided through CPWR's cooperative agreement with NIOSH.

TAKING CONTROL OF WORKERS' COMPENSATION

The National Conference on Ergonomics, Safety and Health in Construction held a special session on the workers' compensation system. It concluded that major reform is urgently needed and that such reform should center on the employers and unions taking control of the system.

The California legislature has made some changes in the workers' compensation system. One of these will enable employers and unions to negotiate benefit levels and procedures for managing worker's compensation.

The legislative change in California, which was initiated and promoted by the Building Trades and the Bechtel Construction Group, aims to provide injured workers better benefits while reducing overall costs. This will be done through better prevention of injuries and better claims management.

The program is still being developed in California. But a pilot effort by Bechtel Construction and the Building Trades in western Massachusetts already has been a resounding success. The pilot program was negotiated by Bechtel Construction Company and the Pioneer Valley Building Trades Council.

The union and employer representatives agreed on overall benefit levels and the following key administrative features:

- *Prevention first.* The employer and workers commit themselves to eliminating injury risks. In western Massachusetts, injuries are way down.
- *Alternative dispute resolution.* A tiered system of ombudsmen, mediators, and arbitrators resolves disputes over claims before any legal proceedings begin. In western Massachusetts, there have been no contested cases.
- *Managed care system.* The parties agree to a list of medical providers and specialists to handle diagnosis, treatment, and rehabilitation. A case manager is assigned to ensure that the injured worker gets needed treatment. By structuring medical care, this system makes it possible to avoid delays, duplications, and unnecessary procedures.
- *Early return to work.* Injured workers are given opportunities for work as soon as possible and ask assignments reflect the workers' physical limitations. Since workers' compensation benefits are lower than wages, this is good for the worker, as well as the employer.
- *Good data.* At every step, careful collection and analysis of data are critical to understanding and preventing injury risks and structuring improved medical delivery and rehabilitation.

If this approach works as well as expected, it will be good for everyone. Both employers and union leaders are enthusiastic about



it. According to Robert A. Georgine, president, Building and Construction Trades Department, AFL-CIO, and president of CPWR, "This approach appears to be a win-win proposition." Certainly, Georgine is putting his money where his mouth is. As chairman and chief executive officer of Union Labor Life Insurance Company (ULLICO), he just announced that ULLICO has established a new subsidiary to write workers' compensation for union employers, initially in California. The new subsidiary is called USA Casualty, and its workers' compensation strategy follows the approach outlined above.

An excellent video that premiered at the national conference explains the need for this type of labor-management approach. Produced by the National Erectors Association, the video is called "The Casino." To obtain copies of the video, contact the NEA at 703-524-3336.

CPWR GOES ON-LINE

CPWR has on-line access to the following services:

LaborNews - provides access to new OSHA regulations, publications, and news releases.

OSHAROM - provides information on OSHA regulations, field operation manuals, and OSHA library catalogues.

Grateful Med - provides access to information from thousands of medical journals at the National Library of Medicine.

CDC Wonder - (Wide-ranging On-line Data for Epidemiologic Research) provides access to public health data sets.

RTKNET - provides access to information from EPA's Toxic Release Inventory (TRI) which contains information on toxic emissions.

And there's more... Call the CPWR Library at 202-962-8490 for more information.

CPWR ADDS FOUR NEW PROJECTS

As part of its existing cooperative agreement with NIOSH, CPWR added four new activities to its ongoing construction safety and health research program. These projects, which began September 1, 1993, include:

Contractor Injury and Illness Data

In cooperation with the National Constructors Association, injury and illness data will be collected from some of the largest construction firms in the United States. These data will be compared to average rates of all construction based on man-hours worked in various industry sectors. The purpose is to identify the most effective components of existing safety and health programs, with the long range goal of developing a model program for mid-size to small contractors.

Exposure Assessment Model

Because of the episodic nature of exposure in construction, CPWR has instituted a program with the goal of developing a construction industry task-based exposure model (see article on page 4). The development of the exposure monitoring instrument will involve characterization of exposure in all sectors of the industry. The Occupational Health Foundation, West Virginia University, and George Washington University are subgrantees to CPWR on this project.

Regional Conferences

As a follow-up to CPWR's National Conference in July 1993, four to five regional conferences will be held in the spring/summer 1994. Tentative locations are: Las Vegas, Atlanta, Seattle, Boston, and Chicago (see article on page 3).

Small Studies Program

To facilitate construction safety and health research and to provide a mechanism designed to respond quickly when opportunities arise in the industry, CPWR has implemented a Small Studies program. About ten to twelve projects will be funded by CPWR this fiscal grant year, with a funding level up to \$20,000 per project (see article on page 1).

NEWS FROM NIOSH

The National Institute for Occupational Safety and Health (NIOSH) has found that construction had the most deaths and second-highest death rate from injuries on the job in the U.S. in the 1980s. NIOSH will soon release nationwide statistics clearly showing the type and extent of deaths from work-related injuries in the United States. The report, *Fatal Injuries to Workers in the United States, 1980-1989: A Decade of Surveillance*, provides — for the first time — detailed data on these occupational deaths for a 10-year period.



NIOSH hopes to use the information about the work-related deaths to identify risk factors and better target its resources to prevent injuries in the workplace.

The report is dedicated to the 63,589 American workers who lost their lives while simply trying to earn a living in the past decade. For this period, the average annual work-related death rate for all employment was 7.0 per 100,000 workers. Motor vehicle crashes (23%), machine-related incidents (14%), homicides (12%), falls (10%), electrocutions (7%), and being struck by falling objects (7%) were the leading killers.

Construction had the second-highest average annual death rate per 100,000 workers (25.6), preceded by mining (31.0) and followed by transportation/communication/public utilities (23.3). The largest number of deaths were in the construction (18%), transportation/communication/public utilities (18%), manufacturing (14%), and agriculture/forestry/fishing (12%) industry divisions.

The report also revealed that black workers had the highest death rate (6.5 per 100,000 workers), while the largest number of deaths occurred among white workers. In addition, the death rate for males (9.8) was 12 times higher than for females (0.8).

The states with the highest occupational injury fatality rates for the private sector were Alaska (34.8), Wyoming (29.0), Montana (21.0), Idaho (16.7), and West Virginia (15.7).

NIOSH used statistics from the National Traumatic Occupational Fatalities data base, which uses death certificates from 52 vital statistics reporting units in the 50 states, New York City, and the District of Columbia. The data base covers workers aged 16 years or older who died from a work-related injury.

NATIONAL CONFERENCE SHOWS SOLUTIONS EXIST FOR CONSTRUCTION SAFETY AND HEALTH PROBLEMS

Labor and management having been working on construction safety and health problems for decades and often these problems seem insolvable. Yet at a National Conference in Washington DC in July, the message was different. It was that solutions do exist and we, in the United States, need to figure out strategies to implement them. This three-day conference got together more than 800 contractors, union workers, government regulators, insurance companies and academics from all over the United States, along with dozens of construction safety people from around the world to discuss what we



can do now to prevent injuries and illnesses in construction. Some of the stories they had to tell were surprising.

A special session on Wednesday July 21 was devoted to "success stories." Manfred Heimann of the Institute for Occupational Safety in Germany told how concerns about silicosis among sandblasters led German researchers to experiment with other sandblasting methods to reduce exposure. They found that wet blasting methods reduced exposures by about 90%. Silica was also banned for non-essential uses. As a result many workers will be saved from silicosis.

Pekka Roto, M.D. of the Tampere Regional Institute of Occupational Health in Finland, discussed the problem of cement dermatitis. Cement dermatitis was identified in Finland as a leading cause of occupational illness among construction workers. Cement can cause two types of skin problems: allergic dermatitis and irritant dermatitis. The allergic reaction, like being allergic to poison ivy, is the more severe and has been linked with hexavalent chromium (chromium VI) in the cement. The addition of small amounts

of ferrous sulfate to the cement changes the hexavalent chromium to a less hazardous form (trivalent chromium) and reduced the allergic dermatitis problem dramatically. The cost of adding ferrous sulfate was only one dollar per ton of concrete.

Jan C. den Nijs, deputy director of Stichting Arbow, the union-employer-run construction safety organization in the Netherlands, told about the problems they identified with the handling of bricks. Bricklayers have enormous back injury problems, in part due to the number of bricks they have to lift (3 to 4 tons per day) and the way bricks are handled. The Dutch worked with the brick manufacturers, union, and management to develop a new manufacturing and delivery system to allow for bricks to be delivered in packages that can be broken down easily and moved by special dollies directly to where they will be used. This reduced the amount of handling tremendously.

Hearing loss is another major problem among construction workers. Bygghälsan, the Swedish organization for construction safety and health, began a national program to prevent hearing loss among construction workers in Sweden in the 1970s, according Göran Engholm, Ph.D., their resident researcher. The Swedes have given hearing tests to more than

1 million workers in the past 20 years, worked with equipment manufacturers to reduce sound levels from equipment, and developed programs to encourage the use of hearing protectors.



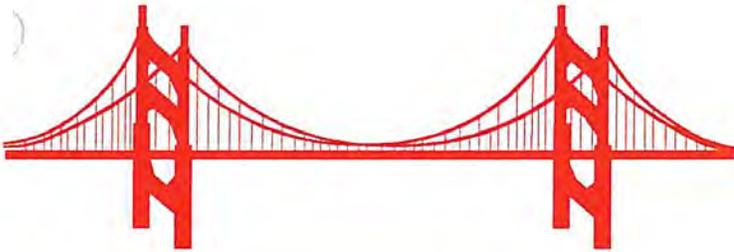
Hearing tests demonstrate that many workers' hearing has been saved by this program. In 1974, when the program began, only about half of construction workers had normal hearing at age 29 and only 20% had normal hearing by age 40. By 1990, 70% had normal hearing at age 29 and about 40% had normal hearing at age 40. Even with the improvements there is still much more to do.

These and many other stories gave those at the National Conference hope that, yes, we can make a difference. Our job for the coming years is to work out strategies to duplicate the successes of Europe here in the United States. This will be one of the goals of the research efforts at the Center to Protect Workers' Rights.

MODEL SPECIFICATIONS TO PROTECT WORKERS FROM LEAD NOW AVAILABLE

Iron workers, painters, and other trades working on lead-painted steel structures are at risk of receiving lead exposures many times over the legal limit for construction set by the U.S. Occupational Safety and Health Administration (OSHA). Many of these exposures occur on state highway bridges that are being rehabilitated or demolished. Short-term effects of high lead exposure include stomach cramps, headaches, and sore muscles and joints. Long-term effects include damage to the reproductive and nervous systems and hypertension.

This is not a problem that individual contractors can solve alone. Contractors that include the cost of a lead protection program into job bids often wind up losing jobs to lower bidders that don't figure worker protection into cost estimates. So, the responsibility must begin with owners. Owners pay for and define the work that contractors do. So, owners can help to protect workers by writing job specifications that clearly require a lead safety and health plan.



A broad-based working group convened by the Center to Protect Workers' Rights (CPWR) and the Steel Structures Painting Council (SSPC) has helped develop such specifications. The document, *Model Specifications for the Protection of Workers from Lead on Steel Structures*, provides model language that can be used by state and federal transportation agencies, city governments, and owners conducting work on lead-painted steel bridges, elevated highways, railway trusses, water tanks, and other steel structures.

SSPC, based in Pittsburgh, is a professional technical society dedicated to developing and improving steel coating technologies. For a copy of the specifications, write to Lead Specifications, CPWR, 111 Massachusetts Avenue, N.W., Washington, D.C. 20001 or call 202-962-8490.

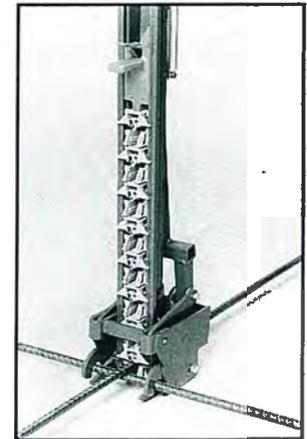
ERGONOMICS TRADE SHOW FEATURES NEW TOOLS FOR CONSTRUCTION

To show ways construction work can be made safer, the *National Conference on Ergonomics, Safety, and Health in Construction* featured a trade show. More than 20 manufacturers from the United States and Sweden exhibited ergonomically designed tools and equipment for construction.

The Swedish construction safety organization, Bygghälsan, has for many years been working to develop construction tools to reduce worker injuries. Swedish manufacturers now include Inter Ergo Svenska, Viio Design, and Munkensbruk. Other manufacturers — Ingersoll-Rand, Sullair Corporation, and Sandvik Saws & Tools, among others — have been entering the market.

How can a tool help prevent injuries? Here is one example: Concrete reinforcement workers tying rebar (iron rods used to reinforce concrete) together by hand suffer from many back injuries. This is because of the enormous amount of time a worker must spend bent over tying rebar. To solve part of the problem, the Swedes have a tool for tying rebar from a standing height, called a Nanjomat.

The tool is like a giant staple gun which the worker operates by pushing down on the handle. One tool is for tying the top layer of rebar. Another is for tying the bottom layer and puts chairs under the rods to raise them up to proper height. The Swedes also use a rebar station or rack to keep the stock close to the work and keep the rods sorted by size.

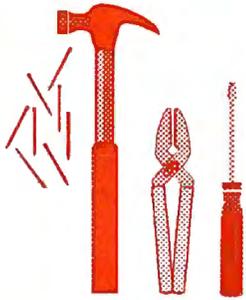


Nanjomat

Another example: Janne Lundh from the Swedish company, Munkensbruk, showed a new saw blade he developed to solve an old problem. When a worker is sawing wood, the saw can slip and cut the worker. This is because it is hard to start the cut. Lundh's saw blade has smaller teeth on the front; they make it easier to start the cut. Larger teeth at the back of the blade (near the handle) are for cutting. (See *TOOLS*, page 10)

TOOLS from page 9

Other items at the trade show included:



- A dollie with handles and wheels that can easily be turned sideways. This makes it easier to carry heavy materials around the building site — and can reduce muscle strains.
- New earphones. They cut out loud, unwanted sounds but make voices clear. This can help save workers' hearing, while letting workers stay aware of what is going on around them. So, if someone needs to warn a worker about something, the worker will be able to hear that.
- Jackhammers and chipping hammers that have much lower noise and vibration levels. These can help prevent some hearing loss and carpal tunnel syndrome.
- Larger handles on tools. A two-handed screwdriver, for instance, is much more powerful and reduces stress on the wrist.
- Special clothing for workers, which is more comfortable and has pockets to hold kneepads in place. Kneepads can help limit injuries to carpet installers, tilers, and others.

For more information on these new products, write to Scott Schneider, CPWR, 111 Massachusetts Avenue, N.W., Washington, D.C. 20001, or call 202-962-8490.

The Center to Protect Workers' Rights (CPWR) - the research arm of the Building and Construction Trades Department, AFL-CIO - is uniquely situated to serve workers, contractors, and the scientific community. Through a cooperative agreement with the National Institute for Occupational Safety and Health (U60/CCU306169), CPWR works to improve safety and health in the construction industry.

REGIONAL CONFERENCES PLANNED

**LOCATIONS INCLUDE: ATLANTA, BOSTON, CHICAGO, LAS VEGAS, SEATTLE
SEE ARTICLE ON PAGE 3**

IMPACT
ON CONSTRUCTION SAFETY AND HEALTH

Building and Construction Trades Department, AFL-CIO/
Center To Protect Workers' Rights
815 16th Street, N.W. - Suite 603
Washington, D.C. 20006
(202) 347-1461



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APPENDIX 10

Template for Solutions Database

What is SOLUTIONS?

SOLUTIONS is an international computer database that informs users about practical ideas and solutions which have been applied to specific health and safety problems. It also gives you a chance to share your own experience in solving health and safety problems - valuable information that is difficult to find in books.

SOLUTIONS will handle any topic within the context of occupational health and safety - physical hazards, safety and ergonomics, from medicine to chemicals.

Simple, straight forward solutions make a big difference in the workplace - if you know about them. Sometimes more complex solutions are needed.

SOLUTIONS gives you access to all of them, simple practical ideas as well as the more complex ones.

SOLUTIONS provides information on effectiveness if available. Diagrams and pictures are also used to make the solution as clear as possible.

Who uses SOLUTIONS?

SOLUTIONS is intended for everyone - workers, health and safety committee members, managers - anyone who would like to see how other people have dealt with health and safety problems.

Why use SOLUTIONS?

You should use SOLUTIONS because it allows you to learn from other people's experience as you search for solutions for your own workplace health and safety problems. It helps you to prevent workplace injuries and illness. It saves you time and money by helping you find solutions that are already available. Why waste your resources re-inventing the wheel?

Where do SOLUTIONS come from?

The solutions come from you. Individuals, organizations, associations and others have already contributed.

Why contribute to SOLUTIONS?

In partnership with CCOHS, SOLUTIONS makes it possible for your organization to reach thousands of people around the world who will benefit from and recognize your commitment to workplace health and safety.

Once part of SOLUTIONS, the information you contribute is

permanently stored in a form that is easily retrieved from any location, anytime. Organizations with multiple locations say that this is particularly helpful.

How can you contribute to SOLUTIONS?

To contribute to SOLUTIONS, simply fill out the attached form and send it to the Canadian Centre for Occupational Health and Safety. Other means of submission may be possible so long as the criteria in the Contributor Form are met. Call us and we can discuss it.

How can you access SOLUTIONS?

The SOLUTIONS prototype is conveniently available either on a floppy diskette or on a CD-ROM compact disc called OSH PUBLICATIONS -- one of the new occupational health and safety discs being produced at CCOHS.

SOLUTIONS CONTRIBUTOR INFORMATION

Please use the attached form as a guide. Leave blank questions that do not apply to your situation.

SOLUTIONS is intended to inform users about practical solutions which have been successfully applied to specific problems in the workplace. Please ensure that solutions submitted are accurate and conform to the following criteria:

- * Relate to occupational health and safety
- * Identify a specific problem and the solution actually implemented and the results achieved (e.g. reduction in hazard, injury, illness, etc.)
- * Are complete and understandable
- * Provide practical, usable information
- * Are not solely a vehicle for product vendors to promote their products
- * Were not detrimental to the interests of workers or employers in the workplace
- * Were implemented with consultation between workers and employers

All solutions are classified under one of three categories. Solutions which meet all of the above criteria are categorized as Type 1.

Where there is no assurance that the solution had involved consultation between workers and employers, it is categorized according to the type of organization contributing the solution. The alternate types are:

Type 2 - government, government agency or bipartite association (worker/employer) association; or

Type 3 - university or private organization.

If there was not consultation between workers and employers, or if you are not sure, we can still accept your solution, and it will be categorized accordingly.

Those solutions included in the database reproduce the original information provided by you as closely as possible. A final copy of the solution record will be returned to you for review.

Illustrations

We will be using computer scanning technology to create graphics.

Your cooperation in providing clear diagrams enables us to represent your solution accurately. We appreciate receiving original material (no photocopies or facsimiles) if at all possible, and will be happy to return them to you at your request.

If you already have electronic diagrams in the PCX or any compatible format, we may be able to use them.

We may also be able to use information from videotapes or other forms, but costs may be involved.

Thank you for taking the time to contribute to SOLUTIONS. Sharing experience on solving occupational health and safety problems benefits everyone.

Please direct questions or return completed forms to:

Heather Reichheld
Canadian Centre for Occupational Health and Safety
250 Main St E Hamilton, Ontario L8N 1H6
(416) 572-2981 FAX (416) 572-2206

SOLUTIONS - CONTRIBUTOR FORM

SOURCE OF INFORMATION:

Organization

Address

City

Province/State

Postal Code/Zip Code

Contact Person

Title

Telephone: ())

Fax: ())

Did this solution involve consultation
between workers and the employer?

Yes ___ No ___

WORKPLACE

Industry:

Operation:

Occupations Exposed:

No. of Employees Exposed:

PROCESS

Description:

PROBLEM

Description of the health and safety problem:

Description of the resulting exposures, injuries or illnesses:

SOLUTION

Type(s) of approaches (please select one or more approach from the list given below):

Engineering:

Personal Protection:

Changes in work practice:

Administrative:

Employee Education:

Other:

Description:

Materials/Equipment Used:

Description:

Commercially available? Yes ___ No ___

Manufacturer/Supplier:

Address

Item:

Cost:

Date:

Special design:

Cost:

Date:

Life Expectancy:

Effectiveness of Solution:

Exposure:

Injury Rate:

Absenteeism/Turnover:

Productivity:

Cost of Operation:

Employee satisfaction:

Other:

NOTES (Include any relevant information not indicated elsewhere)

Please attach illustration material and return to:

Heather Reichheld
Canadian Centre for

Occupational Health and Safety
50 Main Street East
Hamilton Ontario
Canada L8N 1H6

APPENDIX 11

List of Washington Area Study Team Members and
Agenda from 9/13/93 Meeting

MEMBERS FOR WASHINGTON AREA STUDY TEAM

CONTRACTOR REPRESENTATIVES

Stan Manvell	J.G.Davis Corporation
Eric Waterman	National Erectors Association
Jim Sprague	George Hyman Company
George Conley	Poole and Kent Plumbing Contractors
Joe Dunn	Mid-Atlantic Steel

UNION REPRESENTATIVES

Mike Dorsey	Washington DC Building Trades Council
Jerry Lozopone	IBEW Local 26 and Washington DC BCTC
George Hindle	Ironworkers Local 201
Bob Brooks	Roofers Local
Bill Kaczorowski	Baltimore Building Trades Council

RESEARCHERS

Pete Stafford, Chairman	Center to Protect Workers' Rights
Scott Schneider	Center to Protect Workers' Rights
Pam Susie	Center to Protect Workers' Rights
Jim Weeks and/or Laura Welch	George Washington University
Charles Austin	Occupational Health Foundation

CENTER TO PROTECT WORKERS' RIGHTS- WASHINGTON AREA STUDY TEAM
SEPTEMBER 13,1993- 1:30 PM- AT ULLICO BUILDING TENTATIVE AGENDA

- 1) INTRODUCTIONS- 10 MIN
- 2) REVIEW OF THE CPWR'S PROGRAM- PETE STAFFORD 15 MIN
- REVIEW OF WORK ON THE IAM SITE
- 3) PURPOSE OF THE WASHINGTON AREA STUDY TEAM- PETE STAFFORD
10 MIN
- 4) ERGONOMICS PROGRAM- SCOTT SCHNEIDER 20 MIN
- DISCUSSION OF INTERVENTION STRATEGIES
- ERGONOMICS VIDEO
- 5) EXPOSURE ASSESSMENT PROGRAM- PAM SUSI 20 MIN
- DISCUSSION OF PILOT EXPOSURE ASSESSMENT FORM
- REAL TIME MONITORING PROJECT/CAPABILITIES
- 6) SETTING PRIORITIES FOR RESEARCH 20 MIN
- 7) IDENTIFICATION OF SITES FOR STUDY AND LOCALS FOR FOCUS
GROUPS 15 MIN
- 8) SETTING DATE FOR NEXT MEETING

APPENDIX 12

Field notes from Roofing Site Visits in California

NOTES FROM SITE VISITS TO ROOFING JOBS IN CALIFORNIA 4/93

Site visits were made to three roofing jobs in California on April 26-27, 1993. The visits were made in conjunction with Roofers Local #95 in San Jose, CA as part of their ergonomics program under a grant from CAL-OSHA. The three jobs visited were a residential development in San Jose, a commercial office building in San Jose and a tear-off job in Redwood City/Burlingame. The residential job entailed installation of concrete tiles on new housing. The commercial job involved a hot asphalt roof. The tear-off was from a small commercial building. The visits included: Dan Smith, Business Agent for Roofers Local 95, Lee Oftedahl who works for the Roofers Joint Labor-Management Apprenticeship Program, Jan Perez who was hired under the grant, and Ira Janowitz, an ergonomist/physical therapist from Oakland, CA. Talks were held with workers at each site and jobs were videotaped. Measurements of force and weight were made with an analogue Chatillon strain gauge. Below are our preliminary observations:

Residential tile installation

The residential job we observed was tract housing in the Silver Creek Valley Development on Arezzo Drive in San Jose. Two different types of concrete tile were being installed on roofs there: flat tiles (approximately 12" X 18") and corrugated tiles (approximately 24" X 18"). Tasks that were performed as a part of this job were: loading tiles on the roof, laying tiles, cutting tiles with a saw on the roof, measuring/marketing the position of the tiles on the roof, nailing tiles in place, moving tiles around on the roof, and discarding the excess tiles or debris. Several things we noted about this operation: tiles are always laid in the same direction because of the tongue and groove design of the tiles, workers rarely stand up and generally bend in full flexion or hyperflexion at the waist saving their knees by sacrificing their backs, older workers tend to lay tiles one at a time while younger workers lay three at a time. The tiles weigh about 7.5-8 lbs. each for the flat tiles and about 10 lbs. for the corrugated ones. The pneumatic nail gun used to nail the tiles in weighed about 9 lbs.. The saw used to cut the tiles weighed about 28 lbs. Loading the roof is generally done from a forklift pallet. Tiles must be manually transported from the pallet on the side of the roof to the proper placement on the roof for installation. Tiles are often tossed between workers to save time and steps. Tossing and catching can require awkward postures and long reaches with twisting to maintain balance on the roof. Tiles are generally stacked in stacks of six along the roof. The roofer reaches out over 30 inches to pick up half a stack (3 tiles) and then places them at foot level side by side twisting to each side as they are placed. This requires full flexion of the torso, particularly when laying the first line of tiles at the roof's edge. Subsequent lines of tiles are less awkward to lay as they are laid in front of the feet and there is more room for workers to stand. Some workers

lay tiles one at a time instead, primarily the older workers, but this practice is frowned upon by supervisors who feel it is slower. There is some interest in testing this question as to which method is ergonomically better and which is more productive.

This work is done on a sloped roof so the feet are at an inclined angle. Often the worker will spread his/her feet wide apart for stability. One possibility why the worker generally maintains a full flexion with knees straight is that this posture is necessary to keep the center of gravity in front of them to avoid falling off the roof. Others maintain it is to conserve energy. It is likely a combination of both explanations. Work is generally very fast, with one row of tiles (about 20 tiles) laid in less than a minute. Often tiles must be moved out of the way to allow for laying of the next row or the end of the row. This requires considerable amount of materials handling, often moving six tiles at a time (up to 60 lbs.), although generally they are not moved far. Marking the position of the tiles also requires extensive flexion of the body and twisting, as the marking is done at shoe level and to the side of the body. Nailing the tiles in place with the pneumatic nail gun is fast, but requires the worker to bend over for accuracy to make sure the nail goes through the hole. A miss results in broken tiles. Discarding the broken or excess material means tossing the material into a bin off the roof. Care must be taken to not miss the bin, generally tosses are made from some distance to avoid having to carry the tiles back and forth to the bins, so more force is required.

Commercial asphalt roof installation

The second jobsite we visited was a commercial asphalt roofing job in Los Altos, CA. Buckets with wheels were filled with asphalt from a pipe coming from a truck at ground level. The bucket is wheeled into position. A mop is placed in the bucket and pumped to fill it with asphalt. It is lifted out and used to mop asphalt onto a rectangular space about 3 feet by 12 feet. The filled mophead weighs about 30 pounds. Mops have very long handles (about 6 feet long) which allow for considerable leverage for lifting the mops out of the bucket. Workers usually handle the mop from the end, using the middle as a fulcrum to obtain maximum leverage. Mopping is a skilled activity. Roofers refer to it as dancing with the mop. The mopper is constantly twisting the mop handle with both wrists to obtain an even coat. Novices attempt to scrub with the mop and tire quickly. Eventually they develop their technique which apparently minimizes the amount of force required. Mopping is generally done in a figure eight pattern. The force required to mop will also vary depending on the temperature and viscosity of the asphalt. The hotter and more liquid the asphalt, the easier it is to mop. Temperature is also correlated with exposure to asphalt fumes.

After mopping an area, a long cover sheet is laid out adjacent to the mopped area and then "flopped" over onto the asphalted area by one worker on each end and tamped down into place. Gravel is spread on the edges of the sheet to cover excess asphalt. Flopping requires a full body bend and a full twist to the side and then picking up the sheet with an extended reach. Sheets can weigh as much as 72 pounds. On larger jobs, a felt machine is used which puts asphalt and sheets on automatically as the worker pulls the machine backwards.

"Minimoppers" are also used on some jobs to spread asphalt. They have an asphalt bin which releases the asphalt at the bottom as the worker pulls the mopper backward. The bin must be angled downward as it is depleted of stock. Some on them have an X shaped handle, effectively three sets of handles- upper, middle and lower, so that the mopper can be handled at waist height at all times. That is, when the mopper is full and tipped up, the lower handle is used. At mid-fill, the middle handle is used. When almost empty, the upper handle is used when the mopper is tipped back.

Commercial tearoff

The third job we visited was a commercial roof tearoff job in Redwood City, CA. The roof being removed had apparently been installed improperly. A new coversheet was placed over a damaged roof to make it look new and had to be removed only three months after installation. The roof had two other layers underneath which had to be removed. They were wet as well because of the rain which had penetrated the coversheet.

The first step was to cut the coversheet with a utility knife and pull it up by hand. It was then rolled up and dumped in a cart for disposal off the edge of the roof. The bottom layers were attacked with a spade-type shovel. The worker shoved the spade into the roof layers using force to pry up some material and then tore off a piece by hand for disposal. This work required full flexion of the body and considerable force. Once the spade was inserted under the roofing, it was used as a lever to pry the roofing up and as a wedge to get the material to thigh or knee height where it could more easily be pulled up by hand. Ripping off a piece for disposal required a difficult grip between the thumb and four fingers, because the material is so thin. It also requires considerable force and a twisting motion to rip it off.

The material is dumped onto a cart for disposal. We estimated the weight of material on the cart to be about 250 pounds. We measured a maximum force of 72 pounds to lift the cart, an initial force of 43 pounds to begin moving the cart and a sustained force of 30 pounds to push it. The cart is moved over to a ramp with a 5 degree slope. A initial force of 53 pounds is needed to get the cart up the slope and a sustained force of 43-50 pounds to keep it moving up. At the top of the

slope, the cart is tipped up and the debris is dumped into a truck below. A stop board at the end of the ramp is critical to preventing workers from falling off the ramp and helps ergonomically as the workers don't have to pull back on the load to slow it down at the top. The workers worked very fast and it appeared to be very hard work. On larger roofs mechanized equipment can be used. One mechanized roof removal machine is called the "roof warrior" .

One other operation we observed was boring a hole in the edge of the roof parapet to allow drainage. The machine is mounted on the outside of the roof and bores through the edge. It weighed about 55 pounds and was awkward to hoist out over the edge and position on the track which had been installed for the operation.

APPENDIX 13

Field notes from Site Visits to NPR Site

NOTES FROM SITE VISITS TO NPR JOBSITE

9/14/93 - DUCTWORK and DRYWALL HANGING

9/21/93 - MASONRY WORK

10/7/93 - DROP CEILING INSTALLATION

10/21/93 - MASONRY, PLUMBING, DRYWALL HANGING

DUCTWORK

On 9/14/93, during a site visit, sheet metal workers were hanging ductwork in the studio. The studio ceiling is about 20 feet high. The ductwork was a long section with several branches, about 30 feet long and probably weighted about 500 pounds. The ductwork was positioned onto four lifts and hand cranked up to ceiling height by four workers, one on each lift. Once at the proper height, the ductwork had to be connected up to the main system. This was difficult because the upper floor (which had been cut through to make a 2 story studio) interfered with positioning of the forward lift and the duct had to be slid forward while teetering on the lifts. This was a difficult maneuver. One ergonomic problem presented by this work was the need to constantly be looking up. Workers commented that they often had neck strain at the end of the day. The lifts also had to be maneuvered over channels in the floor that had been created for laying cables under the floor. This made moving them difficult. They also were moved frequently while extended and had to be tipped so as not to hit the existing ductwork which was in place. Since they did not fold or have any joints, they had to tip the base and slid it over the concrete floor while tipped under the ductwork.

DRYWALL

Workers were also hanging drywall in the core of the building during our visit on 9/14/93. Drywall carts were being used to transport the drywall around the site, but a lot of hand carrying is still required. Some of the drywall, for the sound proof studios, was 5/8 inch thick and probably weighed about 88-105 pounds a sheet. One of the most difficult parts of drywall hanging is the need to cut it to fit in odd shaped areas and around plumbing and ductwork. Also drywall is cut to close specifications to get a snug fit. This building has about 9 foot ceilings so some drywall fastening must occur overhead which working on ladders.

On 10/21 we interviewed workers and learned that for soundproofing many of the studios were required to have 5 layers of 5/8" drywall, 3 on the outside and 2 on the inside with insulation in between. Based on discussions with a drywall supplier a chart on the weight of drywall was made (attached). Most boards are carried by two people, but even so present an ergonomic risk, especially because of the flexibility of such long boards (10-14 feet long). One drywall hanger estimated that they hang 35-40 boards a day, although it is extremely variable. One inch thick drywall is being used in some areas. This comes

in 2 foot wide boards, because it is so heavy. The rest of the drywall on the job is primarily 5/8 inch, 3/4 inch and 1/2 inch.

MASONRY

Masons were laying concrete blocks in the studio on the fourth floor on 9/21/93. The blocks were solid 8" X 8" X 16" blocks because they were to provide some sound-proofing for the studio. They weighed about 80 pounds each according to the contractor, EGS Masonry. The workers said that they laid about 100-150 blocks per day which translates into 4-6 tons per day, not counting the weight of the mortar. (The foreman said they were averaging 130 blocks per day. He estimated that with the normal hollow blocks, which weigh about 30 pounds, workers lay about 250-300 per day) They said they felt sore at the end of the day. Blocks were loaded onto dollies from pallets, lifted onto the first leg of the scaffold by hand (about shoulder height). Workers then picked them up and stacked them onto the scaffold section nearest the wall being laid. The block stack was on a plank about 2 feet higher than the workers feet and so was at a decent height for working. The work required them to trowel on the cement, turn and place them on the wall, and tamp them down with the trowel. They scaffold they worked on was raised when the next row would have exceeded chest height. The blocks had no place for workers to hold on, being solid and were hard to lift and to place in line. Workers hands were constantly exposed to cement. Cement was mixed in wheelbarrow style buckets and lifted up to the scaffold by shovel-fulls, with the shovel full of cement hoisted overhead and dumped into a pan on the scaffold, about 6 feet high. As the wall got higher (as we observed during our visit 10/21), the scaffold was raised and the blocks had to be handed up many more levels one at a time.

We looked at the ergonomic block from Germany. Workers and the contractor were generally favorably impressed by it and felt it would be safer and more productive. They mentioned a lighter block, made with some aggregate in it, that was made at one time by Supreme Block Co. in Virginia, but the company went out of business and stopped producing this block. The contractor claimed that workers were 25% more productive using the lighter blocks. According to the National Concrete and Masonry Institute, light weight blocks (defined as blocks which use less than 115 pounds/ cubic foot of concrete) are available and constituted 41% of the market in 1991. 3.6 billion blocks were used in the US that year.

DROP CEILING INSTALLATION

On October 7th, I visited the NPR site with an economist from OSHA who will be working on the proposed ergonomics standard. We talked with several workers who were doing drop ceiling installation. They were using a Hilti 350 pole gun to install hangers. The device consists of a bolt gun on an extension pole (about 4 feet long) which can be triggered at the

ase of the pole. Hangers are placed on the tip of the gun, raised to ceiling height and shot into the concrete. Explosive caps are fed into the gun in clips of 10. Triggering the gun requires pressing the tip against the ceiling and pushing up before it can be activated. The number of hangers shot into the ceiling per day will vary, but it is certainly over 100, according the workers. The workers did not consider the recoil from the gun to be problematic, but did complain about the noise. This operation could be helped by a device like the painters disk, to reduce the grip strength needed when holding the pole.

PLUMBING

On October 21, we also interviewed some plumbers installing water pipes overhead on hangers. They said their biggest ergonomic problem was the weight of the materials. Galvanized pipe is particularly heavy. Copper pipe is the lightest and workers often prefer to work with it. Unloading the pipe from the truck is one of the most stressful jobs. Generally workers will carry 3 or 4 pieces of pipe at the same time while unloading it. Pipe comes in 21 foot lengths and larger sizes. Lifting it overhead to install it is awkward and must involve two workers. One worker interviewed, about aged 38, said he had had 3 hernia operations already.

Scott Schneider 10/22/93

WEIGHTS OF DRYWALL BOARDS- 1/2" THICKNESS (1.7 LB/SQ. FT.)

LENGTH	3 FOOT WIDE	4 FOOT WIDE	4 1/2 FOOT WIDE
8 FOOT	40.8 LB	54.4 LB	61.2 LB
10 FOOT	51 LB	68 LB	76.5 LB
12 FOOT	61.2 LB	81.6 LB	102 LB
14 FOOT	71.4 LB	95.2 LB	107.1 LB

WEIGHTS OF DRYWALL BOARDS- 5/8" THICKNESS (2.2 LB/SQ.FT.)

LENGTH	3 FOOT WIDE	4 FOOT WIDE	4 1/2 FOOT WIDE
8 FOOT	52.8 LB	70.4 LB	79.2 LB
10 FOOT	66 LB	88 LB	99 LB
12 FOOT	79.2 LB	105.6 LB	118.8 LB
14 FOOT	92.4 LB	123.2 LB	138.6 LB

WEIGHTS OF DRYWALL BOARDS- 1" THICKNESS (4 LB/SQ.FT.)

LENGTH	2 FOOT WIDE	3 FOOT WIDE	4 FOOT WIDE
8 FOOT	64 LB	96 LB	128 LB
10 FOOT	80 LB	120 LB	160 LB
12 FOOT	96 LB	144 LB	192 LB
14 FOOT	112 LB	168 LB	224 LB

APPENDIX 14

Notes from Training For Plasterer's Apprentices in
Pittsburgh

NOTES ON THE PLASTERERS APPRENTICE TRAINING FEB 20,1993

On February 20,1993, I conducted a training/focus group for a class of nine apprentices from the Plasterer's union in Pittsburgh, PA at Allegheny Community College. The session was one hour long. I first reviewed ergonomic principles for them a bit and discussed ergonomics in construction in general and the ways tools and techniques could be adapted to make them less hazardous. I showed them slides of hazardous jobs and improvements, e.g. new tools. While none of the slides was directly about plastering, I tried to demonstrate principles from them of how jobs were risky and how to reduce risk. Then I posed the question to them of "what parts of your job are the hardest to do? and Why?" The discussion brought forth the following answers:

- 1) Trowelling- While trowels are not particularly heavy, the material being trowelled on (e.g., cement) can be very heavy and combined with the repetitive nature of the work can be stressful on the hand, wrist, arm and shoulder.
- 2) Work on scaffolds- Working on scaffolds is stressful because it requires climbing up and down, often without access stairs or ladders. Workers also have to duck under crossbars a lot to gain access.
- 3) Weather- Weather conditions can be harsh and wearing on workers, e.g. working out in cold weather and winds.
- 4) Smoothing wall surfaces- A "sand bar" or rod is used to smooth out a wall surface after the surfacing material has been trowelled on. This requires pressure to be applied to the wall to keep the rod against the wall while moving it in a horizontal direction. The body is kept in a twisted position to accomplish this. The amount of force required varies as the wall sets or hardens.
- 5) Buckets- Carrying material in five gallon buckets is stressful on the back and hands. Buckets could be redesigned in oval shapes to make them easier to carry. Handles should be more comfortable. One worker suggested that four gallon buckets be used instead.
- 6) Lighting- Lighting is poor on plastering jobs. One worker suggested that workers should wear helmets with lights attached, like miners hats.

APPENDIX 15

Notes from Visit to Rodman's Local #201

Notes on meeting with Rodmans Local 201 in Washington, DC
4/16/93 and other presentations of Glim device

A presentation was made to the Rodmans Local of the Glim Scan system for tying rods. The system was explained and demonstrated to them and the Glim video was shown. The workers were intrigued by the method, but a bit cynical and skeptical. They feel that the bent-over posture is not the biggest factor in producing injuries in their trade. They blame more the materials handling aspects of the job (e.g., carrying rods to and from the stock pile). They also were concerned about the weight of the tool. It seemed rather heavy to them. They did express concerns about the increased productivity and possible loss of work, but on the other hand did not seem particularly impressed with the speed of the tool and felt that an experienced rodman can tie almost as fast as the tool, considering reloading time, etc. They also feel the tool is limited in its usefulness to horizontal slabs. A union contractor is very interested in the tool and the workers will get a chance to try it in a real work situation on his jobs. We expect to show the tool to him in early May.

A presentation and discussion with construction workers at the Building and Construction Trades Legislative Conference on May 19th spurred considerable interest in the device. One Ironworker from Canton, OH was very interested in the device and asked for information and a copy of the video. He was particularly impressed with the Nanjomat because it would specially save time due to the clip chairs.

A Union contractor in Washington, DC who viewed the device and tape at our office last month was very impressed and interested in trying the tool out on his jobs as well.

Contractors from Chicago and New York City have also expressed an interest in trying out the device on their worksites.

Worksite visits are being arranged for July when a representative of GLIM is in Washington for the National Conference.

APPENDIX 16

Faxes Exchanged with L. Lidman of GLIM re: Nanjomat

The Glim Scan System

Tying and supporting of reinforcing bars in one stand-up operation. The bars will be lifted up from the formwork with the Najomat Fixing Tool and the plastic clips will tie and support the bars with the correct support. Capacity; all combinations of bars from Ø 6 mm up to and including Ø 16 mm with 15, 20 or 25 mm support.

Save time – save money

Independent time studies have shown that the time saving with the Glim Scan System, compared with the traditional method, is 40–60%.

This system eliminates the use of supporting bars which also brings a substantial saving.



Ergonomics

The steel fixer performs one of the most injurious and heaviest operations on the building site. "Bygghälsan", The Swedish Organisation for Working Environment, has certified, that fixing steel in a bent-down position, is one of the most trying working operations on the site. Other common injuries among steel fixers are hand scratches, caused by wire ends, crushing injuries etc.

Using the Glim Scan System, all these problems are avoided. The fixing tools adapt the clips from a comfortable upright position. The handles are adjustable in height. Since the clips are made of plastic, no pieces of wire will fall on the formwork, causing rust penetration.



Combinations

The Najomat Fixing Tools for plastic clips are available in two models, G 612-80 (green) and G 1018 (blue).

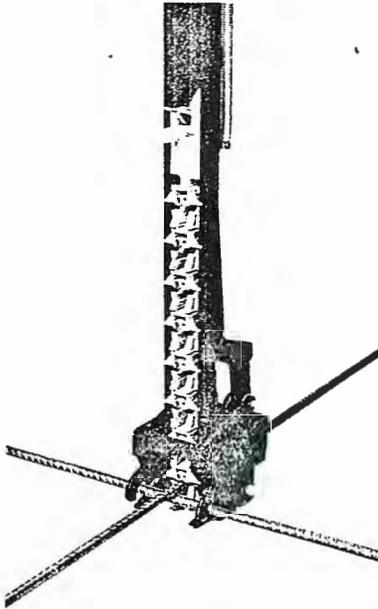
The G 612-80 is designed for supporting of welded mesh \varnothing 6, 8 or 10 mm. Concrete cover 15 mm.

The G 1018 model provide 5 different sizes of clips, depending on which bar dimensions and supports are required. Please see combination guide below. Example: Clip 16/25 means that this clip will tie maximum \varnothing 16 mm bars and give 25 mm support.

Combination Guide Model G 1018

		Upper bar			
		8 mm	10 mm	12 mm	16 mm
Lower bar	8 mm	8/20 10/15C	10/15C 12/20	10/15C 12/20	16/20 16/25
	10 mm	10/15C 12/20	10/15C 12/20	12/20 16/25	16/20 16/25
12 mm	12 mm	10/15C 12/20	12/20 16/25	12/20 16/25	16/20 16/25
	16 mm	16/20 16/25	16/20 16/25	16/20 16/25	16/20 16/25

Najomat Fixing Tool G 1018



Clips fitting:

10/15C, 8/20, 12/20, 16/20, 16/25

Material:

Steel plate, welded and lacquered, all exposed parts hardened. Adjustable handels

Dimesions and weight:

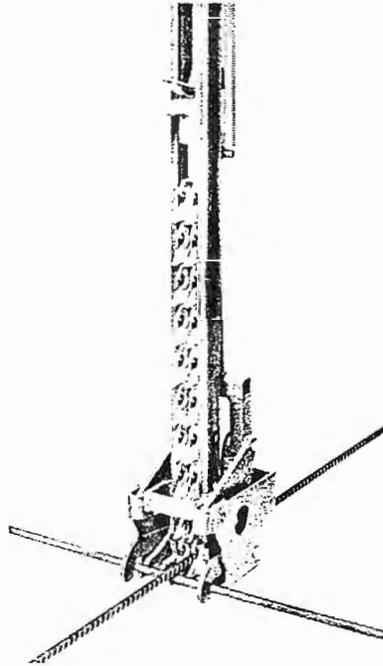
Weight empty:	7.0 kg
Total height:	115 cm
Foot dimension:	7.5 cm (lenght) 10.0 cm (width)

Minimum reinforcement pattern: 50x75 mm
The Najomat can be provided with an extra foot pedal for heavy reinforcement.

Information:

Najomat Fixing Tool G 1018 is designed for simultaneous tying and supporting of reinforcing bars Ø 8 mm up to and including Ø 16 mm in all combinations (see combination guide) Supports 15, 20 or 25 mm.

Najomat Fixing Tool G 612-80



Clips fitting:

6/15, 8/15, 10/15 B

Material:

Steel plate, welded and lacquered, all exposed parts hardened. Adjustable handels

Dimesions and weight:

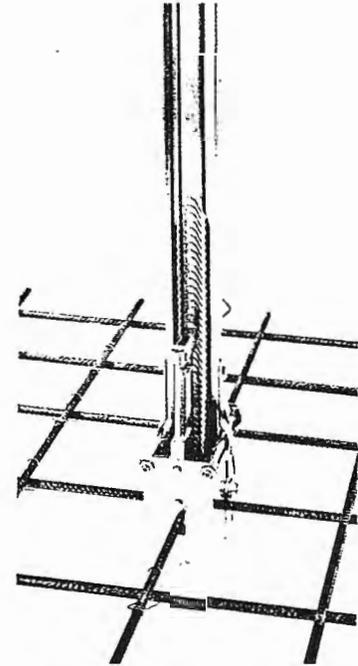
Weight empty:	6.0 kg
Total height:	112 cm
Foot dimension:	7.5 cm (lenght) 10.0 cm (width)

Minimum reinforcement pattern: 50x75 mm

Information:

Najomat Fixing Tool G 612-80 is designed for supporting of welded mesh Ø 6, 8 and 10 mm.
Concrete cover 15 mm.

Najomat Tying Tool G-91



For steel clips 812 and 616:

2 mm spring steel wire

Material:

Steel plate, anodized, all exposed parts hardened. Adjustable handels

Dimesions and weight:

Weight empty:	8.6 kg
Total height:	115 cm
Foot dimension:	17.5 cm (lenght) 9.5 cm (width)

Minimum reinforcement pattern: 60x100 mm
(using Ø 16 mm bars)

Information:

Najomat Tying Tool G-91 ties loose reinforcing bars Ø 6 mm up to and including Ø 16 mm in all combinations. For upper reinforcement in slabs, base slabs (min support 45 mm), bridges etc.
Spring steel clip 812 is used with bar dimensions Ø 6–12 mm, clip 616 is used when one of the bars is Ø 16 mm.



**Rational Products for
Concrete Construction**



BETONGPRODUKTER AB

Box 718, S-601 16 Norrköping, Sweden
Phone: +46 11 108880. Fax: +46 11 161358

TILL TO AN Occupational Health Foundation.....
S. Schneider/Pam Susie.....

FRAN FROM VON GLIM BETONGPRODUKTER AB L Lidman.....

DATUM Feb. 15. 1993..... SIDOR PAGES SEITEN 1.....

Reinforcement tying and supporting

Thanks for your fax of Feb 12 and your interest in our equipment.

We will immediately send the brochures you need.

We will also send you by airfreight 1 sample of the G 1018 and 1 of the tying tool G 91 together with some suitable clips and spring steel wires. In the box you will also find instructions how to use it. The samples are free of charge for you but the airfreight will have to be paid by you.

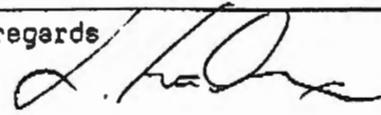
For the actual parking garage project, it would be interesting and important to know the following:

1. When will the project start?
2. What dimensions (in millimeters please) of bars will be used
in A) the lower layer of reinforcement
B) the upper layer of reinforcement
3. What will be the support height in millimeters from the form-work up to A) the lower layer of reinforcement
B) the upper layer of reinforcement
4. Will parallell bars (two bars put close alongside eachother) be used?

Once we know these details we can directly tell you if our equipment is applicable on that project.

As we have told Mr Schneider, our previous attempts to market our equipment in the U.S. and Canada have not been successfull. However, that was 10-15 years ago and we did not have the G-91 then. Hopefully, American construction workers will be more positive to use ergonomic tools today, and maybe also the employers will be more positive to pay for them.
Looking forward to your response regarding above questions.

Best regards



 **GLIM** BETONGPRODUKTER AB

Box 718 • 601 16 NORRKÖPING • Tel: 011-10 88 80

Fax:

011 - 16 13 58



Occupational Health Foundation

1126 16th Street, N.W. • Suite 413 • Washington, D.C. 20036 • 202/887-1980
Fax 202/887-0191

MEMORANDUM

TO: Mr. L. Lidman
Glim Aktiebolag

FROM: Pam Susie, Industrial Hygienist *PS*

DATE: February 26, 1993

SUBJECT: GLIM EQUIPMENT

I'm sorry we are just now responding to your earlier fax. We did get it as well as the requested brochures. I forwarded your questions to the project management firm in Philadelphia right after we got them, but their safety director was out of the office for a week and has not as yet talked to the project designer. However, she assured me she would contact them today and probably get back to me next week. The large parking garage job we hope to pilot your equipment on is already in progress but expected to be ongoing until June of 1993.

Since I was in communication with you last, we have found a second job on which to pilot the equipment. This is a very large federal government building that is expected to take about 2 years to complete. There is a small crew of ironworkers tying steel for footers currently. However, the sub-contractor who has agreed to work with us also has some bridge jobs for which the Glim system may be ideal. He has two going on now that are very near completion.

I spoke to him this morning about the information you requested. They typically use #4 or #5 rods which are 1/2" (12.7 mm) and 5/8" (15.9 mm), respectively. He expects that there will be 3/4" (19 mm) from the form to the lower layer of reinforcement and 6" (152 mm) from the form to the upper layer of reinforcement.

I hope this provides you with the information you need to select the right sample equipment. We are looking forward to trying your system. We would also like to see the video which demonstrates use of the GLIM system. We use video recorders that are capable of playing VHS tapes. I have put in a call to a media specialist to see if they are able to convert VHF videos to VHS. Perhaps Bygghalsan can help us with this as well.

Please let me know if you have any additional questions.

cc: S. Schneider, OHF
P. Stafford, CPWR
K. Ringen, CPWR
J. Dunn, MAS

PS/me



Occupational Health Foundation

1126 16th Street, N.W. • Suite 413 • Washington, D.C. 20036 • 202/887-1980
Fax 202/887-0191

MEMORANDUM

TO: Dona File, Safety Director
LF Driscoll Co.

FROM: Pam Susie, ^{*Pa*} Industrial Hygienist

DATE: February 26, 1993

SUBJECT: PROPOSAL AND GLIM SYSTEM INFO

As requested, you will find 6 copies of a "Proposal to Pilot Ergonomic Tools For Reduction of Back, Hand and Wrist Strain Among Ironworkers" and 6 brochures for the Glim-Scan System.

Please let me know if we can answer any questions you may have about our proposal or the equipment to be piloted.

Enclosures

cc: S. Schneider, OHF
P. Stafford, CPWR
S. Tillett, OHF
K. Ringen, CPWR

PS/me

PROPOSAL TO PILOT
ERGONOMIC TOOLS FOR REDUCTION
OF BACK, HAND AND WRIST STRAIN AMONG IRONWORKERS

Background

The Occupational Health Foundation is a labor sponsored non-profit organization which provides technical assistance and conducts research in the area of occupational safety and health. We are currently sub-grantees to a major initiative to conduct research in the construction industry. This project is being undertaken through a cooperative agreement established between the National Institute for Occupational Safety and Health (NIOSH) and the Center to Protect Workers' Rights (CPWR) in 1990.

Between spring of 1991 and summer of 1992, we conducted an industrial hygiene investigation of the occupational health hazards associated with building a four story office building in the Washington, D.C. metropolitan area. We worked cooperatively with contractors and employees to identify potential exposures and conducted personal air monitoring when it was possible. The major focus of sampling was on asphalt fumes, welding fumes, mineral fibers, dusts and noise.

During the first year of our project, we identified a number of tasks which are ergonomically stressful to workers. Among these was tying steel (rebar), which requires a great deal of bending and rapid, repetitive twisting of the wrist. The Scandinavian literature documented lower back injury among concrete reinforcement workers in the late 1970s (Wickstrom, et al(1978); Saari, et al(1978)). Two-thirds of workers' compensation claims are related to musculoskeletal disorders. Since workers' compensation accounts for 30-40% of payroll costs in construction, preventing musculoskeletal injury would have a major impact in reducing construction costs.

Byghallssan, the Swedish construction industry's organization for working environment, safety and health, has reduced awkward postures and back strain among reinforcement workers through use of a tying device which can be used in an erect position without bending the back or twisting the wrist. The equipment is manufactured by Glim and has been tested by Wiss, Janney, Elstner and Associates for performance in typical slab construction.

Objective

The OHF proposes to work cooperatively with L F Driscoll Co. and Philadelphia Ironworkers in evaluating the efficacy of ergonomically designed tying tools.

Methods

OHF would conduct a site visit to the Vanguard site to videotape existing steel tying practices. An ergonomic analysis of postures and movements would be conducted by OHF using collected video tape. This should take approximately 1 hour depending on work activities occurring at the time of our visit.

Collected video tape would be used to introduce Ironworkers to the purpose of the project. The Glim-scan system would be introduced at this time. This could possibly be arranged with the local to occur during a membership meeting or apprenticeship class. This would take approximately 1/2 hour.

OHF would return to the Vanguard site to pilot use of the Glim-scan system among ironworkers. Work process using the ergonomic intervention would be videotaped. We will have 2 pieces of equipment which we would like to pilot with 3-5 workers for approximately 30-60 minutes each.

The system will be evaluated through analysis of collected pre- and post-intervention videotape. The subjective comments of workers and supervisors who use or observe use of the tool will also be solicited. A preliminary report evaluating the effectiveness of the Glim-scan device in reducing awkward postures among ironworkers and its performance as a tool will be prepared and submitted to LF Driscoll, NIOSH and the local union.



Occupational Health Foundation

1126 16th Street, N.W. • Suite 413 • Washington, D.C. 20036 • 202/887-1980
Fax 202/887-0191

March 8, 1993

Ms. Dona File, Safety Director
L. F. Driscoll Co.
9 Presidential Boulevard
PO Box 468
Bala Cynwyd, PA 19004-0466

Dear Dona:

Thanks again for your cooperation in our efforts to improve safety and health conditions in the construction industry. The rod tying device should be at our office late this week. I will give you a call later this month about trying it out. They will be sending a video which shows the equipment in use.

We are in the midst of writing proposals to the National Institute for Occupational Safety and Health (NIOSH) to request continued support for our projects involving construction safety and health. We mention Driscoll's cooperation in piloting the new tying tool to reduce injury to workers in the proposal. It would be a great help to have a letter from you on your company letterhead stating your willingness to cooperate with us on this project. Your letter of support would be included as an appendix to the proposal. Documentation of support from individuals like yourself demonstrate that we have acquired the necessary cooperation to actually achieve our stated objectives.

The deadline for submission of the proposal is April 1, 1993. So if at all possible, we would need to receive the letter by March 30. I apologize for not getting this request to you sooner.

I look forward to working with you soon.

Sincerely,

A handwritten signature in cursive script that reads "Pam Susie".

Pam Susie
Industrial Hygienist

cc: P. Stafford, CPWR
S. Schneider, OHF
S. Tillett, OHF

PS/me



Occupational Health Foundation

1126 16th Street, N.W. • Suite 413 • Washington, D.C. 20036 • 202/887-1980
Fax 202/887-0191

March 8, 1993

Mr. Joe Dunn
Mid-Atlantic Steel
4253 Montgomery Rd.
Ellicott City, MD 21043

Dear Joe:

Thanks again for your cooperation in our efforts to improve safety and health conditions in the construction industry. The rod tying device should be at our office late this week. I will give you a call later this month about trying it out. They will be sending a video which shows the equipment in use.

As I said last month, we are in the midst of writing proposals to the National Institute for Occupational Safety and Health (NIOSH) to request continued support for our projects involving construction safety and health. We mention MidAtlantic's cooperation in piloting the new tying tool to reduce injury to workers in the proposal. It would be a great help to have a letter from you on your company letterhead stating your willingness to cooperate with us on this project. Your letter of support would be included as an appendix to the proposal. Documentation of support from individuals like yourself demonstrate that we have acquired the necessary cooperation to actually achieve our stated objectives.

The deadline for submission of the proposal is April 1, 1993. So if at all possible, we would need to receive the letter by March 30. I apologize for not getting this request to you sooner.

I look forward to working with you soon.

Sincerely,

A handwritten signature in cursive script that reads "Pam Susie".

Pam Susie
Industrial Hygienist

cc: P. Stafford, CPWR
S. Schneider, OHF
S. Tillett, OHF

PS/me

TILL TO AN
OCCUPATIONAL HEALTH FOUNDATION.....

ATT: S. SCHNEIDER.....

FRAN FROM VON
L. LIDMAN.....

DATUM APRIL 20. 1993..... SIDOR PAGES SEITEN 1.....

RE: GLIM SCAN ACTIVITIES

I would be very interested to hear if you have got any response from contractors with ref. to our equipment. Is it in use? On what kind of sites? What are the eventual reactions so far?

We would be happy to participate in the conference in July. However, the exhibition, travel costs etc. are quite substantial for a small company like ours, and therefore we would need to get the actual feedback from the workers on our equipment before we decide to go.

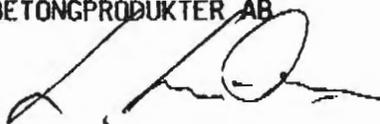
As we see it, and as a result of earlier experience, we think it is necessary that the workers themselves are positive to use our equipment as such. If not, conferences and exhibitions cannot change their attitude. This was what happened earlier in Canada. Everybody was positive, except the workers, who preferred to work the traditional method since it gave them one or two cents extra per tie. If that attitude still remains we do not think it is worth the time and money to participate. I hope you understand this.

We have also told Mr Wos in Stockholm these arguments and we are waiting for our decision before the end of next week. It is therefore important to get your report as soon as possible.

Looking forward to your information within short.

Best regards

GLIM: BETONGPRODUKTER AB



L Lidman

TILL TO AN OCCUPATIONAL HEALTH FOUNDATION
ATT: SCOTT SCHNEIDER
FRAN FROM VON L LIDMAN
DATUM APRIL 27. 1993 SIDOR PAGES SEITEN .2.....

Your fax of April 23

Thanks for your fax. My comments to your meeting with the Rodman Local.,

1. The bent-over working position and the twisting of the wrist when tying together with the hand scratches etc from wire ends, are medically proved to be very injuring. Naturally, the rod carrying is also a very tough job, but has nothing to do with the tying as such. We met the same reaction here when we introduced the System some 20 years ago. It is mostly a "protection attitude" from workers who feel they are doing a good job and do not want anyone to come and tell them how to do it, or how to change things.

It is very important to introduce the Najomats in a proper way, not as something which is going to replace what they are doing now, but rather as a complementary device ment to ease their work where it is possible to use it, that is on the big slabs.

2. The weight The machines have to be built in a certain way to last long, since the handling on the site is extremely tough. Therefore the steel plate has to be of a certain measure etc. We could make them lighter, but at the cost of quality. When being lifted properly - as close to the body as possible - and handles properly adjusted, the weight is not considered being a disturbing factor.
3. The speed Machine G1018 (with plastic clips) ; it is possible that a skilled worker could tie as fast as the Najomat. But don't forget, that the Najomat makes the tie and the supportat the same time. That could never be done as fast manually. Then, the guy has to go over the surface twice, first to support the rods, then to tie them. Machine G-91 (steel clips): This machine has a very high productivity, due to the big loading capacity (100 clips per loading). Please watch the video. It is impossible to compete with the speed of the machine, over the long run.

cont....



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4. Horizontal slabs .

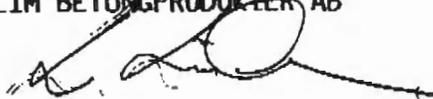
The Najomats are constructed for the horizontal slabs only since the demand for upright working position is strongest here. We are also developing a one-hand operated tying tool for walls, beams etc. But it will take another two years or so before we can introduce it.

Hope this information is useful to you when demonstrating our equipment on the sites. If you feel you need our assistance now, to assist you with the demonstrations etc, please let us know and we will come over directly. It is very important to get a first positive reaction from the workers, since it is them who are going to use it.

Looking forward to hearing from you.

Best regards

GLIM BETONGPRODUKTER AB



L Lidman

July 9, 1993

Mr. L. Lidman
GLIM Betongprodukter AB
Fjärilsgatan 47
(vid Kungsängens flygplats)
Box 718
S-601 16 Norrköping
SWEDEN

Fax. 011-46-11-16-13-58

Dear Mr. Lidman:

I am in receipt of your faxes dated June 22 and July 1. I'm sorry you could not attend our conference and could not arrange to have someone else exhibit your equipment. I will bring the equipment and the video you sent to the conference for people to see. I am sure there will be some interest in the equipment since Eva Holmström will be discussing this technique in her address to the conference. Also a few of the conference participants have called, in response to several talks I have given recently and a paper I wrote, and were interested in the equipment as well. One contractor from Louisiana, Boh Construction, which does a lot of bridge work, is coming and wants to see it.

I can also report that we took the equipment out on to a jobsite today to try it out. The jobsite is a very large Federal office building being built about 20 blocks from my office here in Washington. It will be the largest Federal office building except for the Pentagon. The project is expected to last 4 more years. We took both machines out on the site and the contractor (Joe Dunn of Mid-Atlantic Steel) and a few workers tried tying rebar with them. They were impressed with the Nanjomat and thought it might be very useful. The Tying tool they also liked but they believed that the ties it makes are too loose. The bars can still slide back and forth, which would not be allowed here, at least on this job. One worker also thought the clip chairs allowed too much back and forth movement as well. The contractor thought the tying tool would be most useful for bridge jobs where every junction must be tied. He is planning on taking us onto a bridge job near Annapolis, MD in a few weeks to try it out there.

The contractor had several questions which he asked me to relay to you:

- 1) Do the clip chairs come in other sizes to allow for other heights?

July 9, 1993

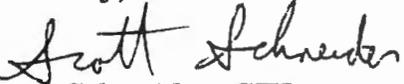
Page 2

2) How much do the clip-chairs cost?

3) Do you have other types of tie wire? There are using epoxy-coated tie wire a lot on bridges where epoxy-coated rebar is primarily used? They also use some galvanized tie wire at times.

I hope you had a good vacation. I look forward to our next communication. I will let you know the reception your equipment gets at the conference.

Sincerely,


Scott Schneider, CIH

TELEFAXMEDDELANDE * TELEFAX MESSAGE * TELEFAXMITTEILUNG *

TILL TO AN CPWR..... WASHINGTON USA.....
KXKXEMAN.....

FRAN FROM VON L LIDMAN, GLIM BETONGPRODUKTER AB SWEDEN.....

DATUM .AUGUST 03 1993..... SIDOR PAGES SEITEN

FOR THE ATTENTION OF MR SCOTT SCHNEIDER

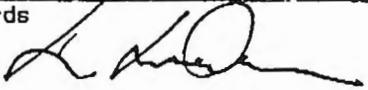
Dear Mr Schneider,
back from holidays I was happy to receive your fax from July 09 which I haven't been able to answer until now. I hope that your conference was successful and that our equipment was of interest. Did you receive the brochures that I sent you? Again I regret that I couldn't attend, but I am sure prepared to penetrate any inquiries that I might get from any US-companies after the conference.

I am surprised that the impression of the Tying Tool was that it made too loose ties. Used on the proper bar dimensions it makes very hard ties. The -616 size that you have should be used on bars not smaller than 16 mm diameter. For smaller bars we have the size -812 as well, covering from 8 mm to 12 mm diameter bars.

Now to you questions:

1. The largest clip we have is the 16/25 for 25 mm height. We do not have larger sizes, depending on that the Najomat cannot lift higher than 25 mm. To be able to use larger clips the whole system would have to be reconstructed. But from what I have learned, the majority heights in the US are 20 and 25 mm. Is that still correct?
2. When calculating the final sales price on the US market, we have to take into consideration that we must include a distributor who will put a margin on top of the price that we could sell to today. We still do not have that distributor and are therefore not able to give any firm sales prices right now. However, my guess would be somewhere in the range of \$ 0.10 - 0.15 a piece for the plastic clips, depending on size, and about \$ 0.06 - 0.08 per steel clip (all at today's exchange rate.)
3. We haven't had any demand so far for epoxy coated wire, It is used here as well but in a very limited scale. We would have to experiment by dipping the whole clip cartridge into epoxy after production. I think it would function but must make tests first.

If you want us to come over for personal assistance just let us know. Looking forward to hear from you again. Best regards



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11:03
011 - 16 13 58

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ROBERT A. GEORGINE, PRESIDENT

September 13, 1993

Mr. L. Lidman
GLIM Betongprodukter AB
Fjärilsgatan 47
(vid Kungsängens flygplats)
Box 718
S-601 16 Norrköping
SWEDEN

Fax. 011-46-11-16-13-58

Dear Mr. Lidman:

I just met with the contractor who is interested in using the GLIM tools. We are going out on to a bridge job on Friday September 17th. We discussed the problem with loose ties and realized that the reason was that the rods were #4 rods, which are only about 13 mm. The bridge job we are going on is using #5 rods which are 16 mm wide, so the tool should work better. However, in the US apparently all bridge jobs use epoxy coated tie wire and rebar. So this contractor says that he would need epoxy coated tie wire to use this machine in the US. Would it be possible to do this? This would be important since bridge jobs would be the most important market for this tool, since every junction must be tied and it is all straight horizontal tying.

This contractor would be very interested in purchasing the machine, if epoxy coated ties could be provided and we can show productivity gains. He is also very interested in meeting you. When do you think you could come for a visit? He could arrange a visit to a site whenever you come and said he would work around your schedule.

I look forward to hearing from you and eventually meeting you.

Best Regards,



Scott Schneider, CIH

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TILL TO: AN CPWR.... WASHINGTON DC.USA.....

FRAM FROM VON L. LIDMAN GLIM BETONGPRODUKTER AB SWEDEN.....

DATUM SEPT 14 1993 SIDOR PAGES SEITEN 1

ATTENTION: MR SCOTT SCHNEIDER

Dear Mr Schneider,

I just received your fax of Sept 13 regarding epoxy wire.

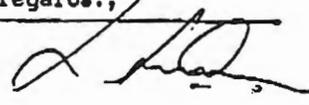
Are you definitely certain that epoxy coated tie wire must be used? I can understand that epoxy coated rods are required in certain constructions since the rods have a constructive function to fill even after the concrete has hardened. But the tie as such has only one function to fullfill: to hold the rods together until the concrete has hardened. After that, it has no function whatsoever. Therefore, conventional tie wire should be accepted even if epoxy rods are required.

Epoxy coating is used to prevent from rust penetration. But if the tie should rust it wouldn't matter, since the rust cannot spread to the epoxy coated rods.

Please observe: One of the reasons why epoxy wire is required might be because normally when you tie by hand, loose wire ends will fall down on the formwork and cause rust penetration on the surface of the concrete construction. But this is eliminated when using our System, since you will not get any loose wire ends.

I would be very grateful if you could talk this over with the contractor in question. Or if you could give me his name and fax number I could discuss with him directly. There are also some other questions that I would have to ask.

We are testing different kinds of coating on the clips and also if anti-corrosive wire could be used. This is, however, rather complicated since our production machinery is not designated for that kind of wire. Hope to hear from you regarding above. Best regards.,



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Fax:

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ROBERT A. GEORGINE, PRESIDENT

September 17, 1993

Mr. L. Lidman
GLIM Betongprodukter AB
Fjärilsgatan 47
(vid Kungsängens flygplats)
Box 718
S-601 16 Norrköping
SWEDEN

Fax. 011-46-11-16-13-58

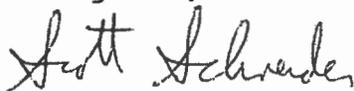
Dear Mr. Lidman:

Thank you for your Fax of September 14. I have checked with the contractor, Joe Dunn of Mid-Atlantic Steel, and he said that the epoxy coated tie wire is required by the State Government in their specifications. He may be able to convince them to delete that requirement, but it may not be easy to get around. He was convinced by your arguments though that epoxy coated tie wire should not be necessary. We did not go out on the jobsite today as planned, because of bad weather. Perhaps next week.

If you want to get in touch with Mr. Dunn directly his office phone number is (301)621-5373 or (410) 465-6399 and his office fax number is (410) 750-8834. But he is rarely in the office and is constantly travelling around to visit sites. I have about three other phone numbers and fax numbers for him at different sites. It may be easiest if you reach him through me, but you are welcome to communicate with him directly. I would like to be kept in the process to learn from it the best way to introduce this and other innovations on the worksite.

One other question has come up in our many meetings: Do you or does Bygghälsan have any data showing reduced injury rates from using the GLIM tools? While we all believe it will be beneficial, it is useful to have statistics showing the health benefits. Please let me know if there is such data available.

Best Regards,



Scott Schneider, CIH

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TILL Mid-Atlantic Steel Corp.
 TO
 AN

FRAN L Lidman, GLIM Betongprodukter AB, Sweden
 FROM
 VON

DATUM Sept. 20 1993 SIDOR PAGES 1
 SEITEN

FOR THE ATTENTION OF MR JOE DUNN

Dear Mr Dunn,

We have got your name and fax number from Mr Schneider of CPWR and first of all I would like to thank you for your interest in our GLIM-SCAN equipment for tying reinforcing rods.

I understand that you have requirement about the coating of the rods and also about the tying wire.

In Europe, we have no requirements of rust protection as far as the tying wire is concerned. The rods however are sometimes (sub-water construction) required to be coated.

In Germany, for instance, stainless tying wire is required, not because of the danger of corrosion withing the construction as such, but to prevent from rust caused by loose wire ends falling down on the formwork. Would this be the reason why epoxy coated wire is required in the US? If so, we should not have any problem, since our spring steel clips do not leave any loose ends at all.

If rust protection still is required, would galvanized wire be accepted? We might be able to produce the clips in galvanized wire. We are currently testing that.

I would certainly appreciate your comments in these matters and also if you could give me some estimations of how much rod tying you make in a year, how many people are involved on the sites etc.

Looking forward to your further comments .

Best regards

GLIM BETONGPRODUKTER AB / L Lidman 

(President)



BETONGPRODUKTER AB

Box 718 • 601 16 NORRKÖPING • Tel: 011-10 88 80

FAXEN

011 - 16 13 58

ANT.SID 02

TELEFAXMEDDELANDE * TELEFAX MESSAGE * TELEFAXMITTEILUNG *

TILL C.P.M.B.....
TO
AN

FRAN L.LIDMAN.. GLIM BETONGPRODUKTER AB.. SWEDEN.....
FROM
VON

DATUM SEPT28.1993..... SIDOR PAGES 2.....
SEITEN

ATTENTION: MR SCOTT SCHNEIDER

Dear Mr Schneider,

For your information I have sent a fax to Mr Dunn (a copy is enclosed) but havent got any response so far. As you said, he is probably hard to get in contact with. Could you assist me in trying to get in touch with him and to answer my message please?

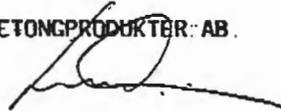
We are currently testing stainless wire and will let you know how the results turn out. Stainless wire would of course be the best solution, but would also cost much more, probably 8 cents/piece instead of 4. (Pse see Price Indications 1993) Would contractors be prepared to pay that?

I would certainly be interested to make a visit. Do you have contacts with other contractors as well that could be visited at the same time?

Looking fwd to you reply.

Best regards

GLIM.BETONGPRODUKTER AB.



L LIDMAN

Fax.nr 011 - 16 13 58



BETONGPRODUKTER AB

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ROBERT A. GEORGINE, PRESIDENT

October 5, 1993

Mr. L. Lidman
GLIM Betongprodukter AB
Fjärilsgatan 47
(vid Kungsängens flygplats)
Box 718
S-601 16 Norrköping
SWEDEN

Fax. 011-46-11-16-13-58

Dear Mr. Lidman:

I took the Nanjomat tools out on to a bridge site last week. Mr. Dunn was not present, as he had a conflict. We showed the tools to the workers there, specifically to the superintendent for the job. We tied a few junctions to demonstrate and encountered a few problems: namely the interference from studs in the decking. Also they felt the ties were too loose. This job was using number 5 rods, which I believe are appropriate for the ties you sent. According to these workers the highway inspectors from the State will not allow any movement of the tied rods. They are very strict. The ties with the Nanjomat did allow some up and down movement, whereas hand ties using a figure eight tie do not allow movement in either direction. Also they stated that their wire spools held about 320 ties verses the 125 ties in the Nanjomat clip. They also raised the problem of the need for epoxy coated ties. The bottom line was that they did not see the usefulness of the tool. I am concerned that I cannot effectively answer their questions and criticisms. I believe they you may be the only person who can do that and hope you can schedule a trip here in the near future. I will explore other contractors and sites we could get on if you interested in coming and can afford it, now that the Dollar is so expensive. Please let me know you plans.

I have also contacted Weelu and Bendof Machine companies regarding their rebar stations, which will help address another aspect of this job, the extensive materials handling which is required.

Thank you again for your patience and cooperation. I look forward to hearing from you.

Sincerely,



Scott Schneider, CIH
Ergonomics Program Director

TELEFAXMEDDELANDE * TELEFAX MESSAGE * TELEFAXMITTEILUNG *

TILL CPWR.....
TO
AN

FRAN L. LIDMAN, GLIM BETONGPRODUKTER AB, SWEDEN.....
FROM
VON

DATUM OCT. 07. 1993..... SIDOR PAGES 2.....
SEITEN

Attention: Mr Scott Schneider

Dear Mr Schneider,

Thanks for your fax of Oct 5 and I certainly appreciate all the effort you are going through presenting our System on the sites.

Number 5 bars are appr 16 mm and should be the ideal rod dimension for the -616 clip. I just come from a site where these rods are used with no sliding whatsoever. Of course, if you tie just a couple of ties on a certain rod you can kick or pull the rod a bit sideways but after the whole surface has been tied with the Najomat, it is not possible to move. Did I understand the problem correctly? You mention that it could be moved up and down. That is one of the advantages with the steel clip. It brings a flexible tie. You can walk on it and after it will always go back holding the rods together in a tight grip. With a conventional tie - after having walked a lot over it - it will loosen up and the rods will start to move.

Basically, I do not think this really is a problem. After all, we know that if you tie a whole slab with the Najomat it will be firm enough and will definitely hold the rods together until the concrete is poured. And after that , its mission is fulfilled.

I think it is more a question of attitudes. If you are positive and really want to use the machine to benefit from its undiscussable preferences., speed, ergonomics and efficiency, you will accept the machine along with the small disadvantages it might have, such as the ones you describe in your fax.

Here, I guess we have another kind of problem. The rodmen feel they are doing a good job tying the rods conventionally. They have been doing that for years and nobody has complained. Suddenly, somebody comes and tells them to do their job differently, using a machine they have never heard of. It is natural that they are sceptical and look for any malfunction they can find. They are probably also afraid of loosing their jobs since

Fax.nr 011 - 16 13 58



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cont. CPWR Att: Mr Scott Schneider

2...

the Najomat does not require any trained labour. anybody could press the handles.

So I think that it really takes a change of attitude towards the machine from the workers. When they really want something to ease their job, they will also accept the Najomat, even if it does not meet their requirements to 100 %.

I guess it would be a good idea to start penetrating the inspectors. If they could be convinced that the Najomat tie is good enough, I do not see why it shouldn't be accepted on the site. So I think the job that you and your organization are doing is absolutely right, to introduce the whole idea of ergonomics among the workers. That is probably what it takes to change the attitudes in the long run. The problem will not be to finding new good products or to convince the employers to letting the workers use them. The problem will be to make the workers change their ways of performing their work.

In Scandinavia, we had exactly the same problems some 25 years ago when we introduced the Najomat System. But here, the workers had a very strong union, tightly linked together with "Bygghälsan". We managed to get our Najomats prescribed in the literature presented to the young becoming workers already in school. It is also a small country that we could cover with our own organization. And maybe the most important: Here, the employers decided not to reduce the rodmen's salary even if the Najomat made the tying 50 % faster. This was very important and the reason was that the employers felt they could benefit from the machine anyway., making the men more efficient, improving the general working environment standard, getting the men to work every day, and so on.

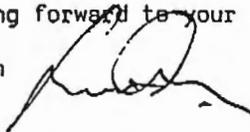
Epoxy coated wire will be impossible to use for us, I'm afraid. Next week, however, we will test stainless wire, which should be even better than epoxy. I will get back to you immediately after that.

If you feel that I could contribute in any way by coming over I would of course do that. But if the whole thing is a matter of changing worker's attitudes towards ergonomic awareness I am not sure that my visit could be a contribution. What do you think?

Please excuse me for using so many words but I really had a need to declare how I feel about the situation.

Eagerly looking forward to your reactions.

Lennart Lidman



APPENDIX 17

Draft Tool Evaluation Form

TOOL EVALUATION FORM

How would you rate this new tool as compared to your old method:

The new tool is:

much easier to use 1	somewhat easier to use 2	no difference 3	somewhat harder to use 4	much harder to use 5
----------------------------	--------------------------------	-----------------------	--------------------------------	----------------------------

What are your impressions of various features of this tool on a scale of 1-5 from not acceptable to acceptable?

Not Acceptable-----Acceptable

Weight 1	2	3	4	5
Handle 1	2	3	4	5
Size 1	2	3	4	5
Height 1	2	3	4	5
Working position 1	2	3	4	5
Ease of operation 1	2	3	4	5
Productivity/Speed 1	2	3	4	5
Force required to operate 1	2	3	4	5

What other things do you like about this tool/technique?

What other things do you dislike about this tool/technique?

Would you continue to use it given the opportunity?

Yes _____ No' _____

If not, why not?

If yes, why?

How much pain do you have after using this tool/technique compared with after working using the old methods?

	much more pain	somewhat more pain	no difference	somewhat less pain	much less pain
Hands/wrists					
1	2	3	4	5	
Arms					
1	2	3	4	5	
Neck					
1	2	3	4	5	
Shoulder					
1	2	3	4	5	
Lower back					
1	2	3	4	5	
Legs					
1	2	3	4	5	
Feet/ankle					
1	2	3	4	5	

APPENDIX 18

Agendas from WMD Consortium Meetings

**REDUCING WORK-RELATED MUSCULOSKELETAL DISORDERS
DECEMBER 21-22, 1992
AGENDA**

Hyatt Regency Washington on Capitol Hill
400 New Jersey Avenue, NW - Conference Level (2nd Floor)
Washington, D.C. 20001

Monday, December 21, 1992

9:00 am - 12:00 pm
Olympic Room

Overall Program Overview
Dr. Knut Ringen, P.I., CPWR
Mr. Scott Schneider, Co.P.I., OHF/CPWR

Status Reports & Future Plans
Dr. Craig Zwerling, Co.P.I., Univ. of Iowa
Dr. David Wegman, Co.P.I., Univ. of Mass.
Dr. Earl Pollack, Co.P.I., GWU Biostatistics Center
Dr. Laura Welch, Co.P.I., GWU Occupational Medicine

NIOSH Overview
Dr. Lawrence Fine
Dr. Marie Haring Sweeney

12:00 pm - 1:00 pm

LUNCH - Bryce Room

1:00 pm - 4:00 pm
Olympic Room
Grand Canyon Room

Individual Working Groups
Hazard Identification/Intervention Working Group
Surveillance Working Group

Tuesday, December 22, 1992

9:00 am - 12:00 pm
Olympic Room
Grand Canyon Room

Individual Working Groups
Hazard Identification/Intervention Working Group
Surveillance Working Group

12:00 pm - 1:00 pm

LUNCH - Bryce Room

1:00 pm - 4:00 pm
Olympic Room

Combined Working Groups

4:00 pm

Adjourn

AGENDA

WORKING GROUP MEETING IN LOWELL, MASSACHUSETTS

**Sheraton Inn-Lowell
50 Warren Street
Lowell, MA 01852
(508) 452-1200**

Monday March 1, 1993

8:45 - 9:00 am	Coffee
9:00 - 10:00 am	Introduction : CPWR Brief Review of Progress by Subgrantees Presentations by: Lowell Iowa GWU GWU Biostatistics OHF/CPWR
10:00 - 10:15 am	NIOSH Ergonomics Overview
10:15 - 10:30 am	Break
10:30 - 11:30 am	Presentation by Henryrik Wos of Bygghälsan on Exposure Assessment
11:30 - 12:00 am	Discussion of Exposure Assessment models
12:00 - 12:45 pm	Lunch (Bechtel video of "Big Dig" will be viewed)
12:45 - 1:45 pm	Presentation by Göran Engholm of Bygghälsan on Surveillance data from Swedish survey
1:45 - 2:15 pm	Discussion of Surveillance and the Swedish data

2:15 - 2:30 pm	Break
2:30 - 3:30 pm	Presentation by Greater Cincinnati Occupational Health Center
3:30 - 4:00 pm	Discussion
4:00 - 5:00 pm	Presentation on Carpenters Union project in Washington State
5:00 - 5:30 pm	Discussion
5:30 pm	Adjourn

Tuesday March 2, 1993

9:00 - 10:00 am	Discussion of plans for next year Setting Date for next Working Group Meeting
10:00 - 12:00 pm	Working Group Meetings
12:00 - 12:45 pm	Lunch
12:45 - 1:45 pm	Working Group meetings continued
1:45 - 3:00 pm	Report back
3:00 pm	Ajourn

NIOSH Construction Consortium Meeting

Iowa City, Iowa

AGENDA

Wednesday, June 2, 1993 - Iowa Room, 3rd Floor

- 8:30 - 10:00 AM Progress Reports - Scott Schneider, CPWR/OHF
Bryan Buchholz, Univ. of Massachusetts-Lowell
Tom Cook, The University of Iowa
Kent Johnson, The University of Iowa
Earl Pollack, George Washington University
Jim Weeks, George Washington University
Craig Zwerling, The University of Iowa
- 10:00 - 10:15 AM BREAK
- 10:15 - 12:00 AM Discussions of year 02 plans - Scott Schneider/listed group above
- 12:00 - 1:00 PM LUNCH in BF236 - 2nd floor
- 1:00 - 3:00 PM Completion of year 02 discussion
- 3:00 - 3:15 PM BREAK
- 3:15 - 4:00 PM Rural Injury Surveillance System - Tom Collins, Craig Zwerling
- 4:30 PM DEPART FOR AMANAS AND TOUR OF MUSEUM
- 6:00 PM DINNER AT AMANAS

Thursday, June 3, 1993 - Big Ten Room, 3rd Floor

- 9:00 - 10:30 AM Job Analysis Techniques - Tom Cook
- 10:30 - 10:45 AM BREAK
- 10:45 - 11:15 AM Labor Management Perspectives
- 11:15 - 11:45 AM Database Issues - Kent Johnson
- 12:00 - 1:00 PM LUNCH in BF236 - 2nd floor
- 1:00 - 2:00 PM Continuation Database Issues/Bibliographies - Kent Johnson
- 2:00 PM DEPART TO CEDAR RAPIDS AIRPORT

APPENDIX 19

Position Papers on Training, Databases, Ergonomic
Exposure Assessment and WMD Surveillance for March
1993 Working Group Meetings in Lowell, MA

POSITION PAPER ON ERGONOMIC TRAINING

At the Ergonomic Working Groups meeting on December 21-22, 1992, there was a brief discussion of ergonomic training. We watched a video from the Ontario Workplace Health and Safety Agency from their Musculoskeletal Injuries Prevention Program (MIPP). The discussion focused on the need to integrate training as part of an overall injury prevention program. It was agreed that training isolated from an overall program would be ineffective. The elements of a training program would generally include: 1) an overview of the types of injuries and risk factors which can lead to these injuries and 2) a discussion to elicit suggestions from workers on how the risk of injuries could be reduced, e.g., by changes in work practices and use of new technology. Because there was not much time for discussion, below are some questions for discussion at the next meeting:

- 1) Training times and format- What is the best vehicle for worker training in construction? Tool box talks only last 5 minutes and do not seem adequate. Should this training be geared towards apprentices and incorporated into apprenticeship programs? Should it be done as part of a local union meeting, e.g. a 1-2 hour evening session? Should there be a 1 hour session on paid time before or after work on the site in a trailer? (Is this even possible?) How can the training be made participatory on the theory that workers know best what hurts and why and how it can be improved?
- 2) Training materials- What type of training materials are best? A video seems essential. Copies of the ergonomics video from the IAM site will be sent to all Working Group members along with a copy of the Ontario videos and a video on back injuries from the Canadian Union of Public Employees (CUPE) featuring our colleague Gordon Atherly. More videotape to be shot this year on sites will add to our inventory of jobs which can be depicted in the final cut. Worker interviews seem particularly effective in such videos, describing how their injuries occurred and the consequences of their injury. Shots of ergonomically difficult jobs must be included as well as possible solutions to stimulate discussion. Success stories would be useful. Written materials could be adapted, in part, from existing generic materials (e.g., the Ontario manual) and the Swedish booklet "Lift, Stand, Carry" which the Construction Safety Association of Ontario had translated into English and published. Do we need a separate instructor's manual with more background information and tips for putting on the training?

- 3) New Technology training- A separate issue is the training of workers to adapt to the introduction of new technology to reduce ergonomic risks. Experience has shown that workers often reject new technology because it seems foreign to them and they need a period to adapt to new ways and be trained on the proper use and the impact it may have on their work and on the risk of injury.
- 4) Contractor/Supervisor training- Training of supervisors and construction managers seems equally, if not more, important as they have control over the site and the work. If work organization is key to solving many ergonomic problems, then their support will be essential. What would such a program consist of and how would it be delivered? What information can we include in it on the costs and benefits of an ergonomics program in construction?
- 5) Leadership training- A training module is to be developed for national leaders and decision makers, e.g. Union Safety and Health staff. What materials should be developed for them?
- 6) Materials development- How can we best coordinate the development of training materials among the subgrantees? Should we send draft materials around for comment? Should we send video segments around? Should we divide up responsibilities for a video, drafting a script, worker materials, supervisor materials, etc? How can we incorporate the experiences from the focus groups? What is our timetable for development and pilot testing of these materials? How will NIOSH assist us with development of these materials (e.g., video production)?
- 7) Trainers- Who should give the training? Initial sessions will likely be given by the consortium members, but ultimately others will take it on. Should worker training be given by apprenticeship coordinators? If not, who?

Hopefully, these questions will help focus and stimulate the discussion at the March 1-2, 1993 Working Group meetings in Lowell, Massachusetts.

Prepared by: Scott Schneider
January 1993

POSITION PAPER ON ERGONOMIC DATABASES

At the Hazard Identification/Intervention Working Group meeting on December 21-22, 1992, there was considerable discussion of database development and use. The purpose of the database is to collect all the information on ergonomics in construction, e.g. hazards identified and solutions, and make it available to as many people as possible to effect changes.

Several different systems were discussed:

- 1) The University of Iowa system which was developed for chemical hazards in construction using Hyperwriter software.
- 2) The NIOSH Hazard Information System for the Mining Industry.
- 3) Ask Sam- database software demonstrated at the meeting by consultant John Harbison.
- 4) A proposal from Gordon Atherley to develop a database of anthropometric measurements on representative construction workers.
- 5) Possible development of a bulletin board system for exchange of more anecdotal information about ergonomic work practices.
- 6) The German GISBAU system for chemical hazards

The User- The type of database(s) that will be developed will depend on the target audience for the information. Possible end users include: Safety and Health professionals, Regulators (OSHA, NIOSH), Contractors, International Union Health and Safety Staff, Local Unions. The Iowa and GISBAU systems have an advantage in that they tailor the information to different audiences. The Ask Sam proposal promoted by OHF was primarily geared towards Local and International Unions and Contractors. The NIOSH system is an on-line system for use by Safety and Health professionals.

Information to be included- The database will/can include: information from published literature and research reports from other countries (e.g., abstracts from Bygghälsen of their research), results from CPWR research efforts, and possibly anecdotal information from contractors and unions about hazards or solutions. The Atherley proposal is to develop a database which includes information from strength testing of representative construction workers.

Access to the information- The Iowa system works by way of an operator who takes requests, accesses the database and modifies the information so the response is pitched at the appropriate level. Responses are stored to use in future similar requests. The Ask Sam database concept is to develop factsheets with essential information identifying ergonomic problems and solutions and make it available on a disk with a read-only version of the Ask Sam search software. This system also has the capability to include visual images. Read-only versions will cost about \$15-\$25 each. The disks would be sent to unions or contractors who would then search the system themselves. Periodic updates could be available. This would be analogous to the way NIOSHTIC and other databases are made available commercially on CD-ROM by the Canadian Center. Information in Ask Sam can be exported into other databases in ASCII format.

Discussion- Clearly all the information that has been accumulated must be stored somewhere in an accessible location. The Iowa system seems ideal for that. We will need to obtain funding for a research position to manage and access that information. Input of the data will also require staff time at both Iowa, OHF and Lowell. OHF and Iowa will have scanners to input information and can coordinate the format and exchange. Lowell can feed information into Iowa by mail. The question is how to provide access to it.

A phone inquiry system is perhaps the simplest in that it requires minimal skills on part of the user, but it requires a sophisticated staff to search the database and prepare appropriate responses. A disk-based system requires a computer and some minimal computer skills, but allows users to look at all the information themselves. The NIOSH mining system requires the most sophistication, in that it is accessed by computer and modem and has a relatively complicated menu of options for information. For all these systems we will have to figure out how to publicize the availability of this information, either the Iowa phone number, the availability of the disks or the NIOSH modem access number.

It was suggested at the Working Group meeting that a needs assessment should be done to see what kind of information people need and how they would find it most useful. Some anticipated uses would include: If a local union official has a workers' compensation case for an injured worker and wants to show that the injury was work related, access to information showing this has been an identified hazard would clearly be helpful to his/her case. If a contractor was concerned about how he/she could reduce their comp. costs by redesign of jobs, searching a database to see what solutions have been devised and where they could be obtained would be very useful. Researchers will likely use the database to identify new research issues or hazards in need of solutions.

For these purposes, we need to assess the ability to include anecdotal information in the database. While there is a certain danger (or possibly liability) in including un-validated information, this may be addressed through the appropriate caveats. Oftentimes ergonomic problems and solutions are identified as they relate to individual tasks. This information could be very useful to other contractors or workers if it can be shared. For this to happen there has to be a mechanism for getting such information into the system. We had

envisioned a 2 page questionnaire which would be widely circulated through the Unions where Local Unions or Contractors could provide the information to be sent to OHF or Iowa for inputting into the system. It would then be accessible through phone inquiry to Iowa or on disk via OHF. Alternatively, a computer bulletin board system could be set up for all to post such information and exchange it. This is a much faster system, but is limited to those who have computer and modem capabilities and skills.

Proposal- One proposal to incorporate all these elements would be to:

- 1) Set up a ergonomics information repository at Iowa with Iowa, Lowell and OHF feeding information into the system.
- 2) Establish a phone inquiry system at Iowa for Safety and Health Professionals and other end users.
- 3) Pilot the development of a disk-based system geared for Local Unions and Contractors as an adjunct to the Iowa system (e.g. similar to factsheets that Iowa would send to a local union in response to an inquiry). OHF would take responsibility for development and piloting of this system.
- 4) Set up a bulletin board conference via Poptel, Labornet, Laborline or Compuserve just for construction ergonomics.
- 5) Explore sources of strength testing data for the database suggested in the Atherley proposal.
- 6) Conduct a needs assessment as part of focus groups meeting this year and at workshops at the National Conference in July.

Prepared by: Scott Schneider
January 1993

POSITION PAPER ON ERGONOMIC EXPOSURE ASSESSMENT

At the Hazard Identification/Intervention Working Group meeting on December 21-22, 1992, there were many options discussed regarding ergonomic exposure assessment. The different systems discussed or distributed included:

- 1) Checklist approach to identify risk factors
 - a) from IAM Site
 - b) from Suzanne Rodgers- GE
- 2) Job factors surveys of workers, Focus groups, Worker interviews
 - a) Tom Cook's Iowa survey
 - b) GWU survey of electricians
- 3) Time studies/work sampling to get estimates of time exposed
- 4) Job Analysis systems
 - a) ARBAN from Sweden
 - b) OWAS from Finland
 - c) Dutch system
- 5) Hi-tech systems for postural analysis from video
e.g., Ariel Performance Analysis System
- 6) Quantitative measurement
 - a) of vibration using accelerometers
 - b) of forces or weights for materials handling tasks,
use of the NIOSH revised lifting guide
- 7) Symptom/discomfort surveys
 - a) Tom Cook's Iowa survey
 - b) GWU survey of electricians

In addition the University of Cincinnati job factors checklist was mentioned.

We discussed the purpose of the exposure assessment. From an industrial hygiene perspective there are two main purposes: 1) to be able to compare hazards and prioritize for intervention and 2) to assess the efficacy of interventions. While many hazards will be obvious candidates for intervention, there will also be many which fall into the gray area where it is unclear if intervention is necessary. This may be particularly true for intermittent work. Use of an exposure assessment tool may help us make judgements about

the magnitude of the problem and the urgency of intervention. In addition, exposure assessment can be important for epidemiological studies, both retrospective and prospective, to help identify the importance of various risk factors and establish dose-response relationships.

Very little exposure assessment work has been done in construction or for risk of back injury, the most important ergonomic hazard in construction. This is borne out in the paper distributed at the meeting on exposure assessment for back injuries (Burdorf, 1992) where a review of the literature published between 1981 and 1990 (81 studies) found 58% with no exposure information. The remainder mostly used questionnaires (33% or observations, including videotape analysis (9%). Only 5% (4 studies) used direct measurements, one used the NIOSH lifting guide and three used vibration measurement.

The Working Group discussion seemed to reach a consensus that a multi-tiered approach is necessary. All jobs would have some minimal checklist or screening for risk factors. Some jobs would be studied in more depth by the use of questionnaires, worker interviews/ focus groups or job symptom surveys, although the reliability of these questionnaires needs to be validated. Job symptom surveys can help identify the magnitude of the problem or part of the body affected, but generally will not identify the hazardous task. Time studies/work sampling was also considered an important part of an analysis to look at the extent of exposure. This would be the third tier analysis. A small subset of jobs would be chosen for more in-depth analysis consisting of one of the postural analysis systems (e.g., ARBAN, OWAS, Dutch). Quantitative measurement of forces (e.g. weights lifted, vibration measurements) would be used in selected cases where it was appropriate and feasible. The Hi-tech video systems would not be used, in part because such a level of sophistication may not be necessary and also because we do not have the tools or training to use such a system at this time.

Working Group members should review the job factors checklists and questionnaires and job symptom survey forms distributed and mentioned for selection of a common form for the initial and secondary analyses at the March 1-2 meeting.

With regard to the merits of the various job analysis systems, the ones mentioned (OWAS, ARBAN, and Dutch system) are the only ones which have been used in the construction system to the best of our knowledge. They all are similar in the factors they rate. Scott will explore and learn more about the ARBAN system to Sweden next month. Articles on each were distributed at the Working Group meeting. Hopefully at the March 1-2 meeting in Lowell, a discussion of the merits will lead to a consensus of which system to use to ensure some comparability between sites.

The choice of jobs to do more in depth analysis on is critical. In part it will be dictated by the construction project we are studying. The Boston Artery project is unlikely to have many drywallers or roofers working on it, so those will have to be the focus of other projects. Because these projects have not yet been visited, in some cases they have not yet been started, and are constantly in flux, a high degree of coordination is needed between the researchers. Monthly phone conversations and/or conference calls would be useful in this respect. Jobs which can be targeted, in part, can be identified initially from the review paper that Scott Schneider and Pam Susie submitted for publication.

Prepared by: Scott Schneider
January 1993

POSITION PAPER ON SURVEILLANCE FOR WMD

During the Surveillance working group meeting on WMD on December 21 and 22, 1992, the discussion was rather open-ended. However, an attempt was made to find common ground among the components of the project. Out of this several issues emerged that we will have to consider over the next few months. The following is a brief discussion of these issues, most of which were not resolved during the meeting.

How do we define a construction worker and how do we define WMD?

We seemed to agree that the separate projects are operating at different levels of surveillance, each with its own objectives. Therefore, it may not be either necessary or desirable to have identical definitions of WMD and or of workers among projects. There seemed to be general agreement that we do not need to have identical definitions. The definitions of each, however, should be consistent with the objectives of the specific project.

What is the purpose of carrying out surveillance of WMD?

The overall purpose of this project is to reduce the incidence of work-related musculoskeletal disorders among construction workers. The surveillance aspect of the project, then, should be able to indicate whether the incidence of these disorders is decreasing. One of the suggestions made was that we not attempt to use surveillance as an epidemiologic tool to identify risk factors for WMD. Rather, we should make use of existing knowledge about risk factors and apply it to design interventions. The surveillance then would involve observing changes in the existence of known hazards rather than (or perhaps in addition to) observing changes in the incidence (or prevalence) of WMD.

How extensive should the surveillance be?

There was concern that we may be spreading ourselves too thin by trying to carry out surveillance for WMD among all of the trades in the construction industry. A suggestion was made that we confine our efforts to those trades that have not been studied sufficiently to determine what the hazards and interventions are.

How do we determine work-relatedness of WMD?

There does not appear to be a clear answer to this question, although each component of the project has some way of approaching this issue. One of the suggestions made was that we might use population-based rates to make comparisons among trades to get at the work-relatedness issue.

How can we interpret repeated cross-sectional studies of worksites?

Cross-sectional surveys of worksites to identify WMD among workers are likely to miss those conditions that are serious enough to cause the worker to be absent from work. We need to find some way to deal with this problem. Related to this is the issue of acute vs chronic exposure. We may be better able to identify the acute exposures than the less intense, but persistent, chronic ones. Unless we are able to find some way to take these factors into account, these repeated cross-sectional surveys will lead to a falsely optimistic picture.

How can we best make use of medical care claims data for surveillance?

One of the components of the WMD project involves the analysis of medical care claims data by linking insurance claims data from local union health and welfare funds with workers' compensation claims in the same state. Some concern was expressed as to whether it was necessary to expend the effort, including dealing with the confidentiality issue, and money to link these data sets. An alternative is to analyze health and welfare claims and workers' compensation claims separately. The latter would not have the advantage of relating claims to the same population. One proposal was to use both approaches in one state and then use the results to extrapolate to other states where it is only possible to use the latter approach.

Prepared by: Earl Pollack
January 1993

APPENDIX 20

Agenda and Minutes for Ergonomics Subcommittee of
CPWR Technical Advisory Board (TAB) meeting July 21,
1993

AGENDA FOR TAB ERGONOMICS SUBCOMMITTEE MEETING

WEDNESDAY, JULY 21, 1993 7:30 AM, SHOREHAM, MONIQUE'S RESTAURANT

- * REVIEW OF THE CENTER'S ERGONOMICS PROGRAM**
- * DISCUSSION OF SITE WORK- LIST OF SITES, TYPES OF JOBS**
- * COORDINATION WITH OTHER RESEARCH EFFORTS**
- * PLANS FOR INTERVENTION STUDIES**
- * BACK BELT STUDY AT BOSTON HARBOR PROJECT**
- * AIHA CONFERENCE-ERGONOMICS AND CONSTRUCTION SESSION- 5/94**
- * PSYCHOSOCIAL FACTORS- WORK ORGANIZATION**

MINUTES

THE CENTER TO PROTECT WORKERS' RIGHTS ERGONOMIC SUBCOMMITTEE MEETING OF THE TECHNICAL ADVISORY BOARD JULY 21,1993 THE SHOREHAM HOTEL, WASHINGTON, D.C.

- 1) The subcommittee reviewed the progress report from Year 1 of the WMD grant and the proposed plans for Year 2. Some concerns were expressed about the work sampling approach taken by Lowell on the Boston Artery project. Some members of the committee felt that methods were not as useful in construction where jobs are changing constantly.
- 2) The subcommittee discussed the local union survey and recommended that more information be provided to explain what ergonomics is, in order to help workers in filling out the survey. Otherwise, they felt information obtained would not be as useful. The subcommittee approved of the concept for a video to be used as an ergonomics trigger video for worker focus group meetings and to educate workers about the ergonomics problem in construction. A draft script was distributed to the committee and, based on their support, CPWR will pursue the production of the video. We anticipate the video will be completed prior to the next TAB meeting in October. Barbara Silverstein offered to get Scott Schneider questions on psychosocial issues from Karasek and Wickstrom for use in future surveys. They also recommended that surveys include a few questions (maximum of 5) on work exposures/activities.
- 3) The subcommittee recommended that CPWR review the study Bob Park (UAW) published in APHA in 1992 of Blue Cross records to see what ICD-9 codes he used in comparison with the list generated by GW.
- 4) The subcommittee was strongly opposed to CPWR's involvement in studies NIOSH is considering on the efficacy of back belts in construction. They felt the exposures were too varied to control to carry out a definitive study.
- 5) The subcommittee felt the CPWR should play a more definite role in bringing together labor and management, along with tool manufacturers, to devise national strategies for interventions, such as new concrete block designs or new tool design. Contests for new tools design could be held; insurance companies could be encouraged to give rebates for the use of new tools; and tools the disabled might find uses for in construction.
- 6) The subcommittee also felt the CPWR should develop a resource library including videos on construction safety and health which could be lent out, as no other organization currently provides this type of information.
- 7) The subcommittee members recommended that fall protection (slips, trips and falls) be included as an integral part of the WMD project. Jerry Purswell volunteered to present a paper on fall protection at the 1994 AIHA Ergonomics and Construction session Scott Schneider is organizing.
- 8) The subcommittee also felt training efforts need to be focused on supervisors as well.

December 28, 1993

APPENDIX 20

CPWR Publications List

Publications

November 1993

Construction Industry Safety and Health Workshop: Proceedings. 1991. Report G1-91.

Summarizes presentations by safety and health leaders from Canada, Finland, Germany, and Sweden at a CPWR-sponsored workshop in October 1991. The workshop was the first of many safety and health forums planned to foster international collaboration in construction.

Feasibility of Evaluating Health and Safety Training of Painters in Three States. 1992. Report P1-92.

Presents results of a 6-month study initiated by CPWR to determine the feasibility of evaluating the effectiveness of health and safety training programs for construction painters in Alaska, Oregon, and Washington.

Model Specifications for the Protection of Workers from Lead on Steel Structures. 1993. Report OSH3-93.

Presents model language for contract specifications covering work involving lead on industrial structures such as steel bridges, tunnels and storage tanks. Prepared by a 50 member working group representing a broad range of interests. There is no charge for this publication.

Pollack, Earl, ScD, and Knut Ringen, DrPH. 1993. *Risk of Hospitalization for Specific Non-Work-Related Conditions Among Laborers and Their Families*, American Journal of Industrial Medicine 23:417-25. Report D2-93.

Compares rates of hospitalization for nonoccupational illness in the United States with those for two health insurance plans organized by local unions of the Laborers' International Union of North America. This study uses medical claims data for 1989.

Research Project Guidelines. 1993. Report P2-93.

Describes procedures for applicants for funding from CPWR of up to two years and up to \$20,000. The money will support applied research in the United States intended to improve safety and health in construction. Opportunistic studies will take advantage of unforeseen or hard-to-predict opportunities to investigate a safety or health problem. Pilot studies will more deliberately define a problem and point up possible innovative solutions. There is no charge for this publication.

Schneider, Scott, CIH, and Pam Susie, IH. 1993a. *Ergonomics and Construction: A Review of Potential Hazards in New Building Construction.* Report E1-93.

Attempts to characterize the ergonomic risks associated with each stage of construction for each craft — and what is known about minimizing the risks. Unlike in other manufacturing, where there is an assembly line, many decisions related to safety in construction are left to the worker.

——— 1993b. *An Investigation of Health Hazards on a New Construction Site.* Report OSH1-93.

Summarizes a 15-month study of worker exposures to toxic substances, noise, and ergonomic risks, and recommends changes in work organization and additional research.

Tillett, Sandra, and Patricia Sullivan. 1993. *Asbestos Screening and Education Programs for Building and Construction Trades Unions*, American Journal of Industrial Medicine 23:143-52. Report OSH2-93.

Describes medical screening programs made available to "high-risk" asbestos-exposed local union members through the efforts of several affiliates of the Building and Construction Trades Department, AFL-CIO. Model asbestos screening and education programs were tailored to meet individual union needs.

Continued ◀

Weeks, James L., Sc.D. 1993. *Lost-Time Injury Rates in Construction, 1975-90*. Report D1-93.

Shows that the rate of lost-time injuries and the number of days lost per lost-time injury have been increasing. The lost-time injury rate for construction — 6.6 per 100 full-time workers — is highest for all sectors in the United States.

Work-Related Musculoskeletal Disorders: A Construction Bibliography. 1993. Report E2-93.

Covers mainly the biomedical, industrial hygiene, and ergonomics literature available from online and CD-ROM bibliographic data bases. This report was prepared by the Department of Preventive Medicine and Environmental Health, College of Medicine, University of Iowa.

Videos

Construction Exposure Monitoring. Video 1-93.

Shows a new approach to assessing exposures to chemical hazards on construction sites. Industrial hygienists measured exposures to asphalt and welding fumes on a new construction site using "real-time monitoring" — measuring exposures to chemicals as they occurred. 5 minutes.

Publications are \$5 apiece postpaid, videos are \$7 apiece postpaid. To order a report or video, send check or money order to, Publications, CPWR, 111 Massachusetts Avenue, NW, Washington, D.C. 20001.



TAB 1

University of Massachusetts - Lowell, Progress Report
Year 1 +

Reducing Musculoskeletal Disorders Among Carpenters
or Related Construction Workers

**REDUCING MUSCULOSKELETAL DISORDERS AMONG CARPENTERS
OR RELATED CONSTRUCTION WORKERS**

University of Massachusetts Lowell

**Progress Report
Year 1 +**

December 6, 1993

I. Access

Working relationships have been established with key personnel on the CA/T construction project. These include Kenneth Paradis, Director of Safety/Labor Relations for Bechtel/Parsons Brinckerhoff (B/PB), the Contract Manager for the project; Joseph Nigro, Secretary-Treasurer and General Agent for the Boston Building Trades Council (BBTC); G. Stewart Young, Safety Consultant for Arthur D. Little (ADL), Safety Consultant/Manager and designated worker compensation liaison for the project; and Sergiu F. Luchian from the office of the CA/T Project Director for the Massachusetts Highway Department (MHD). Detailed discussions with Mr. Paradis and Donald D. White, Deputy Project Manager for Bechtel, as well as Mr. Nigro, have been necessary to gain access to the construction sites. A letter of access from the MHD's CA/T Project Director Peter Zuk was signed on April 22, 1993 (see Appendix 1).

The Research Project Advisory Committee (RPAC) has been assembled and has had its first meeting. Co-Chairs are Kenneth Paradis, Joseph Nigro and Ron Grenier (MHD). The other members are G. Stewart Young; Letitia Davis, Director of Occupational Health, Massachusetts Department of Public Health; James Merloni, Jr., Director of the New England Laborers' Training Center at Hopkinton, MA; and Priscilla Conant, Director of Claims, Massachusetts DIA. *Ex-officio* members are David H. Wegman, Principal Investigator from the University of Massachusetts Lowell (UML); L. Christine Oliver, Principal Investigator on a separate research project studying health and safety on the CA/T construction project from Massachusetts General Hospital (MGH); and Pete Stafford of the CPWR. This Committee will provide the research project with the guidance needed to communicate effectively with and obtain cooperation from contractors and local unions on the site and to target specific sites for examination. In addition, RPAC will aid the research project in the development and implementation of protocols for morbidity data collection and evaluation and in "trouble-shooting" when problems arise. When necessary or advisable, prime contractors and union business managers will be asked to attend RPAC meetings.

The RPAC will meet on a quarterly basis in conjunction with the Labor-Management Safety Committee meetings. Co-Chairs of the two committees are the same. Technical advisors to the Labor-Management Safety Committee are the *ex-officio* members of the RPAC, Laura Punnett of UML, and John Moran of the Laborers' Health and Safety Fund of North America.

On May 27, a meeting was held with local union business agents. A presentation of the project was made and the attendees had a chance to ask questions of the investigators.

A meeting with the contractor representatives was held on June 17. At this meeting, a presentation of this project was made. A number of sensitive questions were raised by the contractors and MHD. As a result of these questions, it was agreed that formal written procedures for access are needed as well as agreements regarding confidentiality and liability. These written agreements have been drafted and should be finalized at the RPAC meeting to be held on December 7.

In preparation for access to the CA/T site, the following activities have been carried out.

1. A project brochure has been designed and printed (see Appendix 2). It will serve to introduce the workers as well as labor and management personnel to the goals and activities of the project.
2. Five initial sites have been identified as having a high probability for meeting our criteria for site work (a site map is included in Appendix 3). Those criteria include: a high concentration of horizontal heavy and highway work, a large projected number of workers, a relatively long term contract and a high likelihood of repetitive and/or heavy manual work. (Employment projections are also included in Appendix 4.) The sites identified range from tunnel finishing work to grading and road construction. The sites and the contractors are as follows:

Site	Description	Contractor
C02A1	South Boston Haul Road	Modern Continental
C04A2	I-90 BMIP Tunnel	Kiewit/Perini/Atkinson/Cashman, jv
C05A1	I-90 Immersed Tunnel	Morrison Knudsen/White/Interbeton, jv
C07A1	I-90 BIF Tunnel	Modern Continental/Obayashi, jv
C07B1	Porter St. Outfall	Cashman

("jv" = joint venture)

3. A procedure has been developed to review each of these sites as access is arranged to determine its appropriateness for both on site exposure monitoring (i.e. work sampling) and direct contact with groups of workers for the purposes of hazard identification, construction of focus groups and training. The procedure consists of the following steps:
 - a. Contact union Business Agent, ADL Safety Consultant and contractor project supervisor for designated site.
 - b. Arrange a first visit to look over site and evaluate the feasibility of doing sampling and having direct contact with workers.

- c. Review production schedules with appropriate personnel. Obtain information on Preliminary Site Visit Report form (see Appendix 5), e.g. which trades are working on site, what are their schedules, how many subcontractors are there and what do the subcontracts involve?
 - d. Discuss best times for work sampling and other activities with appropriate personnel.
 - e. Schedule exposure assessment activities and implement them.
4. A procedure will be set up so that the research team will be notified directly by B/PB when a contract is awarded. In this way the earliest possible contact can be made with the contractor and a relationship can be established before the contractors are under the time pressure which accompanies the on-site work.

Investigators were taken on a tour of the C04A2 site on June 17 and a walkthrough of the same site on December 3.

II. Health Surveillance Program

Investigation of a source-specific process for the identification and tracking of morbidity data for project workers has focused to date on a) First Report of Injury Forms from the Massachusetts Department of Industrial Accidents (DIA); b) health care providers; c) information collected on-site from OSHA 200 Logs and First Aid Logs that record all minor injuries not likely to be captured by other sources; and d) information that will be collected by ADL. Because the wrap-up worker compensation carrier has only recently been named, availability and retrieval of data from this source has not been investigated yet, although the MHD has indicated their cooperation in this regard.

The DIA has agreed to work with the Project investigators to develop a mechanism of targeting and tracking First Report of Injury Forms from the CA/T project. ADL will be collecting morbidity data from site-specific logs, including OSHA and first aid logs, as well as from the worker compensation insurer. There has been agreement 1) to sharing of morbidity data by ADL and Project investigators and 2) to the use of consistent diagnostic codes [Revised Occupational Safety and Health (ROSH)] by Project investigators, ADL, and the DIA. The use of ROSH codes for workers' compensation claims will be explored with AIG, as will the use of ROSH codes for documenting "source/2nd source" of injury/illness and "event or exposure" on this construction project.

Health care providers for injured/ill workers on the project have been designated by B/PB. Those likely to be used most frequently because of their geographic proximity to the project and collective expertise are the Boston City Hospital, Winthrop Hospital, New England Baptist Hospital, Tufts New England Medical Center, the Massachusetts General Hospital (MGH), the University Hospital, and the East Boston Neighborhood Health Center (EBNHC). Providers to be approached regarding participation in the Project in the remaining period of Year 1 have been identified.

A health surveillance questionnaire has been drafted and will be administered to workers at the union hall. An attempt will be made to use CA/T workers but general construction workers may be employed if access to CA/T workers off-site is difficult.

The Health Surveillance activity has now been closely integrated with and depends upon continued collaboration with L. Christine Oliver and her separately funded CPWR project. Further details are provided in that continuation proposal, which is provided as Appendix 6.

III. Hazard Identification Program

An UML Hazard Identification working group has been formed meeting weekly to discuss a plan of action for this section and progress. Members of the working group are: Bryan Buchholz, Laura Punnett, Susan Moir and the two research assistants, Diane Lee and Victor Paquet. Mr. Paquet replaced Evelina Alexeeva in September of 1993.

A. Focus Group Meetings

A format has been developed for implementing focus groups with workers in the different trades on the CA/T site. The method which will be used is based on research into standardized focus group methods^{1,2} and methods used with working class people³. Additional information has been gathered through conversations with focus group experts: Janice Fine, a political consultant presently at MIT in Cambridge, MA; and Sharon Kurtz, Ph.D., at Suffolk University in Boston, MA.

¹ Krueger (1988) *Focus Groups: A Practical Guide for Applied Research*. Sage.

² Morgan (1988) *Focus Groups as Qualitative Research*. Sage.

³ Gamson (1992) *Talking Politics*. Cambridge University Press.

Information accumulated through individual and group discussions with workers in construction have also helped shape the form of these meetings. A group discussion with roofers in western Massachusetts gave insight into group interactions. A separate discussion with Julian DuPont, an ironworker in western Massachusetts, provided much information. A summary of these conversations are included in Appendices 7 and 8.

An introductory level training and group interview was held with the safety consultants of ADL who will have direct responsibility for management of health and safety on the CA/T. This meeting allowed piloting of some focus group methods. This meeting also provided insight into the work currently going on at the various sites of the construction project. A suggested checklist was developed for ADL as a first effort to get ergonomic items included in the safety audits that the consultants will do on-site (see Appendix 9). A summary of this meeting is included in Appendix 10.

At this time, a tentative protocol for focus group meetings has been established (see Plan of Action for Year Two). A demographic questionnaire, a scripted introduction and a prepared script will be used to structure the meeting and have been prepared (see Appendices 11, 12 and 13). Storyboards are being adapted from training curricula materials for use in the focus group meetings. One of these storyboards is a Pain Body Map (see Appendix 14).

A meeting with representatives of the Carpenters and Laborers was held on July 17 to discuss access to the workers for Focus Group meetings and other face-to-face exchanges. Similar meetings are planned with the Operating Engineers and Iron Workers.

B. Develop Program Protocol/Collect Data

A bibliography of construction hazards and interventions is being compiled. References have been entered into a bibliographic software database. The bibliography includes references from international authors and uses keywords appropriate for this study (see Appendix 15).

A formal work sampling procedure has been developed and piloted. This procedure has been given the name PATH for Posture, Activity, Tools and Handling analysis. A detailed description of this method is contained in Appendix 16. PATH work sampling forms have been and will be customized for each trade studied. An example of the PATH work sampling forms that

have been used is in Appendix 17. A cover sheet will be used for documenting site specific information (Appendix 18).

The form allows coding of postural data using a modified version of the OWAS system^{4,5}. A description of the modified OWAS codes that will be used is in Appendix 19. Other sections of the form will be divided into gross motor activities and fine motor activities. Tasks listed on this form will vary depending on information gathered in the focus group meetings and initial walkthroughs of the construction site.

Initial work sampling was performed on roofers in Lowell, Massachusetts. Work sampling procedures have been further tested on mechanics, carpenters, ironworkers and laborers at various sites in the Lowell and Lawrence, Massachusetts and Nashua, New Hampshire area.

While awaiting access to the CA/T site, further piloting of the PATH method has been accomplished on a union highway construction site in Plymouth, Massachusetts. This site is owned by the MHD and involves work on routes 3 and 44. An example of the data that have been collected in Plymouth are contained in Appendix and 20.

As a result of the pilot work in Plymouth, the hierarchical taxonomy used by the Massachusetts Highway Department (Appendix 21) has been adapted for use on this project to describe the process of highway construction. The construction process is first broken into stages, which may include: earthworks, tunneling, drainage, sub-base/pavements, structures and utilities. Each stage is divided into several operations, e.g. earthworks may include: clear and grub, excavation, screeding and pile driving. Each operation is further separated into tasks and the trade involved in each task is identified.

IV. Ergonomic Training Program

There are three objectives for the first stage of the training component of the project:

⁴ Karhu, Hansi, Huorinka (1977) Correcting working postures in industry; a practical method for analysis. *Applied Ergonomics* 8:199-201.

⁵ Karhu, Harkonen, Sorvali, Vepsalainen (1981) Observing working postures in industry: examples of OWAS application. *Applied Ergonomics* 11:11-13.

1. To provide introductory information to workers on ergonomics.
2. To involve the workers in a participatory method of learning.
3. To develop training materials that are adaptable to a variety of training conditions.

An UML Ergonomic Training working group has been formed meeting approximately monthly to discuss a plan of action for this section and progress. Primary members of the working group are: Craig Slatin and Susan Moir. The activities of the training working group in the first year have centered on two areas:

1. Speaking with construction workers, management personnel and other people involved in construction in order to determine the needs for and feasibility of training in the construction sector.
2. Reviewing sources relevant to the subject of worker education.

Within these two areas, the following activities have been completed:

1. Individual and group interviews about the construction field and training needs have been conducted with ironworkers and roofers (See Appendices 7 and 8). Informal discussions have also taken place with carpenters, bricklayers and electricians.
2. Interviews about workplace education curriculum and techniques have also been conducted with Makund Narayan of the Carpenters' Health and Safety Fund ergonomics training program and with Sue Thrasher and Mary Jo Connelly of the Labor/Management Workplace Education Program at the University of Massachusetts Amherst.
3. Three sources on techniques and strategies in worker education have been reviewed^{6,7,8}. One of them⁶ was found to be particularly relevant to training issues in construction.

⁶ Wallerstein, Weinger (1992) Health and safety education for worker empowerment. *AJIM* 22:619-635.

⁷ Baker, Stock, Szudy (1992) Hardware to hardhats: Training workers for action (from offices to construction sites). *AJIM* 22:691-701.

⁸ Arnold, Burke, James, Martin, Thomas (1991) *Educating for a Change*. Doris Martin Institute.

4. An introductory level training and group interview was held with the safety consultants of ADL who will have direct responsibility for management of health and safety on the CA/T (see Hazard Identification).
5. The Work Environment Program's NIEHS-funded Hazardous Waste Workers Training Program has provided consultation on training, curriculum development, and manual production.
6. A training session on ergonomics in construction was held for a group of twenty-five ironworkers and roofers from western Massachusetts and a group interview was conducted with the roofers.
7. Training materials from other sectors of labor, office, production and transportation have been reviewed for their relevance to the construction sector.

These interviews and the information obtained from them have informed our development of materials to meet the three objectives of the first stage of the training component. Two versions of an introductory module are being developed:

1. **Ergonomics Awareness (Appendix 22)** is a short introduction to the basic language and concepts of ergonomics, cumulative trauma disorders, risk factors and health effects. It is modeled on "toolbox" or "tailgate" training and can be adapted to short blocks of time.
2. **Ergonomic Storyboards (Appendix 23)** are a series of 4-5 posters based on the Ergonomics Awareness training and used in the Focus Groups to stimulate discussion and reinforce unfamiliar concepts.

Each of these modules can be used in a variety of settings which may become available now that access to the CA/T has been granted. They are adaptable to the variety of conditions that may occur from a few workers to many, from a 15 minute toolbox meeting to a longer block of time conducive to a more comprehensive training session, from meeting the workers at the union hall to a company-called meeting on the job. In addition, these modules will provide a foundation for the next stage of objectives which will involve the development of more advanced training in consultation with the Core Group that will be assembled in the second year of the project.

ADL -- ARTHUR D. LITTLE
AIG -- AMERICAN INDUSTRIAL GROUP (Insurance Company)
B/PB -- BECHTEL/PARSONS BRINCKERHOFF
BBTC -- BOSTON BUILDING TRADES COUNCIL
CA/T -- CENTRAL ARTERY/TUNNEL
CPWR -- CENTER TO PROTECT WORKERS' RIGHTS
DIA -- DEPARTMENT OF INDUSTRIAL ACCIDENTS
EBNHC -- EAST BOSTON NEIGHBORHOOD HEALTH CENTER
MGH -- MASSACHUSETTS GENERAL HOSPITAL
MHD -- MASSACHUSETTS HIGHWAY DEPARTMENT
MIT -- MASSACHUSETTS INSTITUTE OF TECHNOLOGY
NIEHS-- NATIONAL INSTITUTE FOR ENVIRONMENTAL HEALTH SCIENCES
OWAS -- OVAKO WORKING POSTURE ANALYSIS SYSTEM
PATH -- POSTURE, ACTIVITY, TOOLS AND HANDLING
ROSH -- REVISED OCCUPATIONAL SAFETY AND HEALTH
RPAC -- RESEARCH PROJECT ADVISORY COMMITTEE
UML -- UNIVERSITY OF MASSACHUSETTS LOWELL

APPENDICES

1. Letter of access, April 22, 1993.
2. Project brochure.
3. Map of CA/T construction project.
4. Employment projections.
5. Preliminary Site Visit Report form.
6. "Boston Central Artery/Harbor Tunnel Construction Project Health and Safety Hazard Evaluation" Renewal Application.
7. Summary: Group discussions with roofers in Springfield, Massachusetts.
8. Summary: Conversation with Julian DuPont, Ironworker.
9. Ergonomic exposure audit checklist.
10. Summary: Meeting with ADL consultants.
11. Discussion group questionnaire.
12. Introduction to focus group meetings.
13. Focus group script.
14. Pain body map.
15. Key words for computerized bibliography of ergonomic construction hazards and controls.
16. PATH method description.
17. Work sampling form.
18. Work sampling form cover
19. Modified OWAS posture c
20. Example PATH data.
21. Hierarchical taxonomy of
22. Ergonomic awareness mo
23. Ergonomic storyboards.

APPEN
Tab 4

USP
CAN

TAB 1

APPENDIX 1

Letter of access, April 22, 1993.



Massachusetts Highway Department
Central Artery/Tunnel

April 22, 1993

Mr. Theodore G. Weigle, Jr.
Project Executive
Bechtel/Parsons Brinckerhoff
One South Station, Boston, MA 02110

RE: Health and Safety Hazard Evaluation Study
Massachusetts General Hospital/University of Massachusetts in
Lowell Research Team. B/PB Letter I93-769

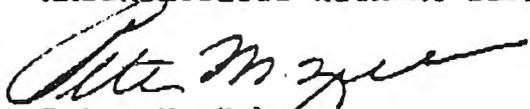
Dear Mr. Weigle,

The Department has reviewed the proposed study work program submitted by the above-referenced research team and concurs with B/PB's recommendation to grant access to Central Artery/Tunnel construction sites. We expect the site visits will be scheduled and coordinated by the B/PB Safety and Health office and our Safety consultant, ADL.

Please coordinate this subject with Sergiu F. Luchian of my staff, who will also represent MHD on the proposed Advisory Committee.

Sincerely,

MASSACHUSETTS HIGHWAY DEPARTMENT


Peter M. Zuk
Project Director

cc: R. Grenier
C.M. Davis
S.F. Luchian *SL*
EN-1.1.2

093-1537

TAB 1

APPENDIX 2

Project brochure.

Just some of the many hazards that can affect construction workers and to which you may be exposed on the Central Artery/Tunnel:

- Repetitive work
- Chemicals
- Noise
- Vibration
- Stress
- Heavy lifting
- Dust
- Awkward postures
- Fumes
- Confined spaces

Research Team

UMASS Lowell / Dept. of Work Environment
Telephone: 508-934-3258

Susan Moir
Project Coordinator

Bryan Buchholz, PhD
Assistant Professor

Laura Punnett, ScD
Associate Professor

David Wegman, MD, MSOH
Professor and Chair

Robert Karasek, PhD
Professor

Rafael Moure-Eraso, PhD
Associate Professor

MGH / Occupational Health Associates
Telephone: 617-726-3741

L. Christine Oliver, MD, MS
Director

Assistant Professor, Harvard Medical School

Penny Snell
Project Administrator

Mark Braverman, PhD
Instructor, Harvard Medical School

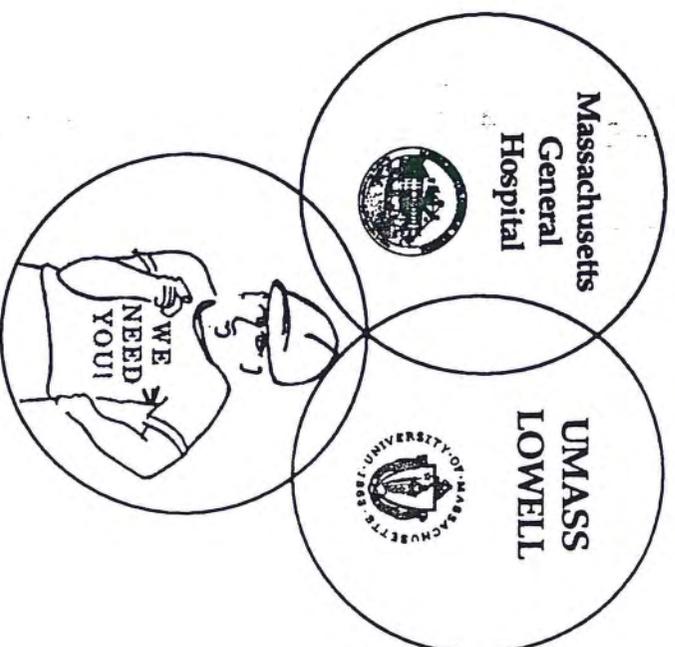
Center to Protect Workers' Rights / AFL-CIO
Telephone: 202-962-8490

Knut Ringen, DrPH, MPH, MHA
Director

Pete Stafford
Senior Project Coordinator

Call us if you have questions or would like to be more involved.

BOSTON AREA UNION CONSTRUCTION WORKERS



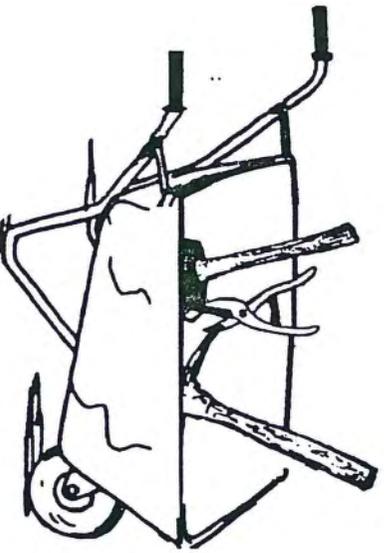
Health and Safety

on the

Central Artery/Tunnel

Construction

Project



Construction Work:

It doesn't have to be so dangerous.

Be part of the change.

The Center to Protect Workers' Rights (CPWR) has received a grant from the National Institute of Occupational Safety and Health to study the safety and health of construction workers on Boston's Central Artery/Harbor Tunnel project. CPWR has contracted with the University of Massachusetts Lowell and Massachusetts General Hospital to examine the health effects of work on heavy and highway construction.

YOU ARE THE EXPERTS AND WE ARE ASKING FOR YOUR HELP. You will see us at various sites. We may ask you to fill out a questionnaire or to talk with us about your work and its potential risks.

CPWR, a non-profit research arm of the AFL-CIO's Building and Construction Trades Department, whose 15 unions represent 4 million construction workers, is a major center for data related to safety and health in construction. It is uniquely positioned to serve workers, contractors and the scientific community.

Project Goals

To seek a better understanding of occupational health and safety risks for construction workers by:

- identifying the hazards involved in heavy and highway construction
- classifying the health and safety effects of these hazards for workers in each of the construction trades

To work with construction workers to prevent illness and disease among workers doing this type of construction, now and in the future.

Prevention measures may include:

- worker training in identifying and solving hazardous situations
- changes in work organization to decrease the risk of injury
- new technology and tool design to reduce safety and health problems

Research Activities

DISCUSSION GROUPS

- to talk with workers in various trades about the nature of construction work and health and safety on the job

HEALTH EVALUATIONS

- with individual workers, at union halls or on site
- limited physical examinations (testing lung function, joint range of motion, etc.)

ENVIRONMENTAL SAMPLING

- analyze air and soil for selected contaminants

EVALUATION OF PHYSICAL WORKLOAD

- observe workers on site to identify body postures, lifting, tools and equipment used, etc.
- take photographs and videotapes

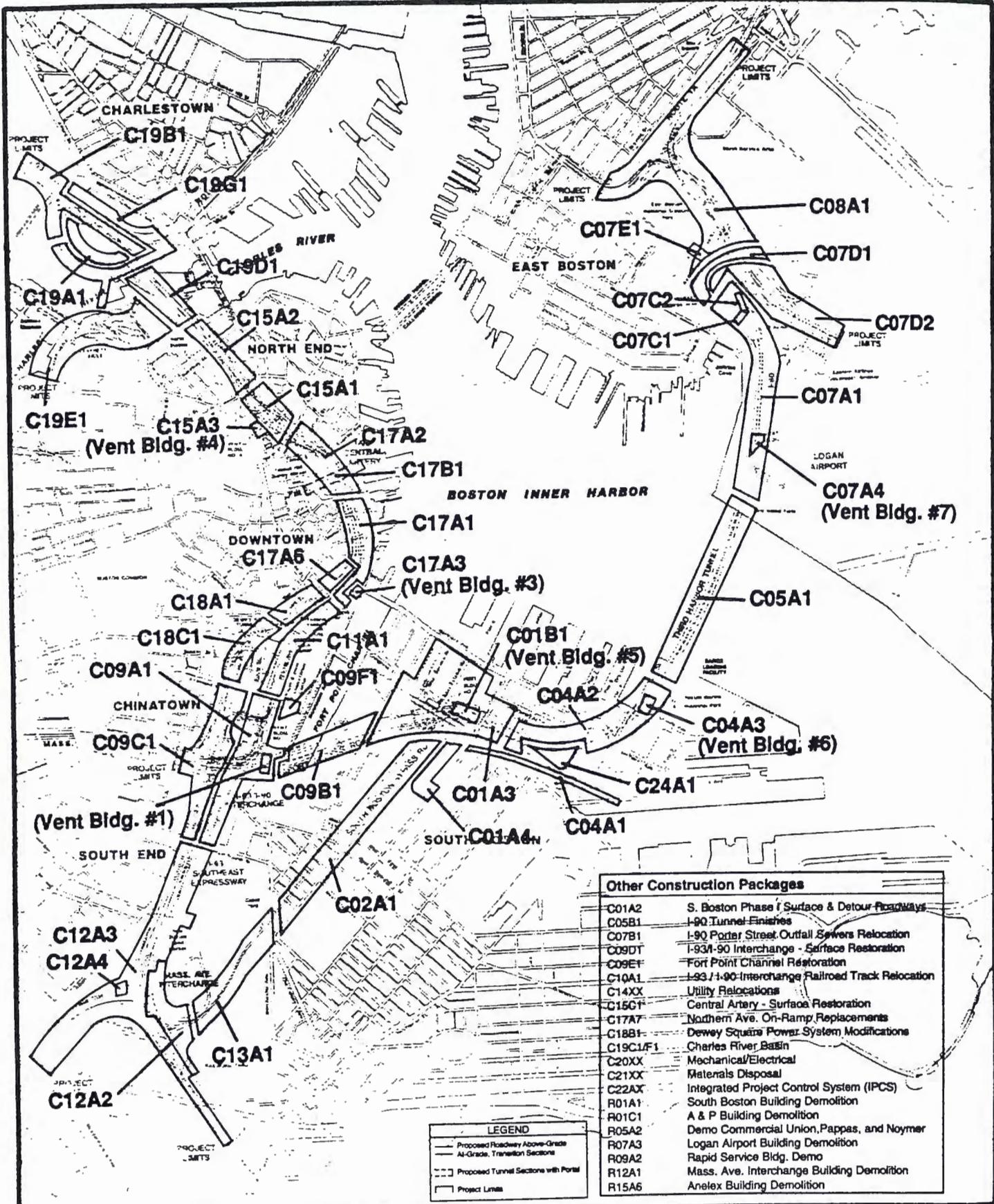
TRAINING

- provide information on ergonomics and prevention of work-related musculoskeletal disorders to workers, supervisors and contractors

TAB 1

APPENDIX 3

Map of CA/T construction project.



Other Construction Packages	
C01A2	S. Boston Phase I Surface & Detour Roadways
C05B1	I-90 Tunnel Finishes
C07B1	I-90 Porter Street Outfall Sewers Relocation
C09DT	I-93/I-90 Interchange - Surface Restoration
C09ET	Fort Point Channel Restoration
C10A1	I-93/I-90 Interchange Railroad Track Relocation
C14XX	Utility Relocations
C15C1	Central Artery - Surface Restoration
C17A7	Nodern Ave. On-Ramp Replacements
C18B1	Dewey Square Power System Modifications
C19CLF1	Charles River Basin
C20XX	Mechanical/Electrical
C21XX	Materials Disposal
C22AX	Integrated Project Control System (IPCS)
R01A1	South Boston Building Demolition
R01C1	A & P Building Demolition
R05A2	Demo Commercial Union, Pappas, and Noymer
R07A3	Logan Airport Building Demolition
R09A2	Rapid Service Bldg. Demo
R12A1	Mass. Ave. Interchange Building Demolition
R15A6	Anelux Building Demolition

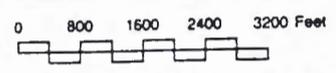
LEGEND
 - - - Proposed Roadway Above-Grade
 ——— At-Grade, Transition Sections
 [] Proposed Tunnel Sections with Portal
 [] Project Limits

KEY
 MAP
 3

Construction Contract Packages

October 1992

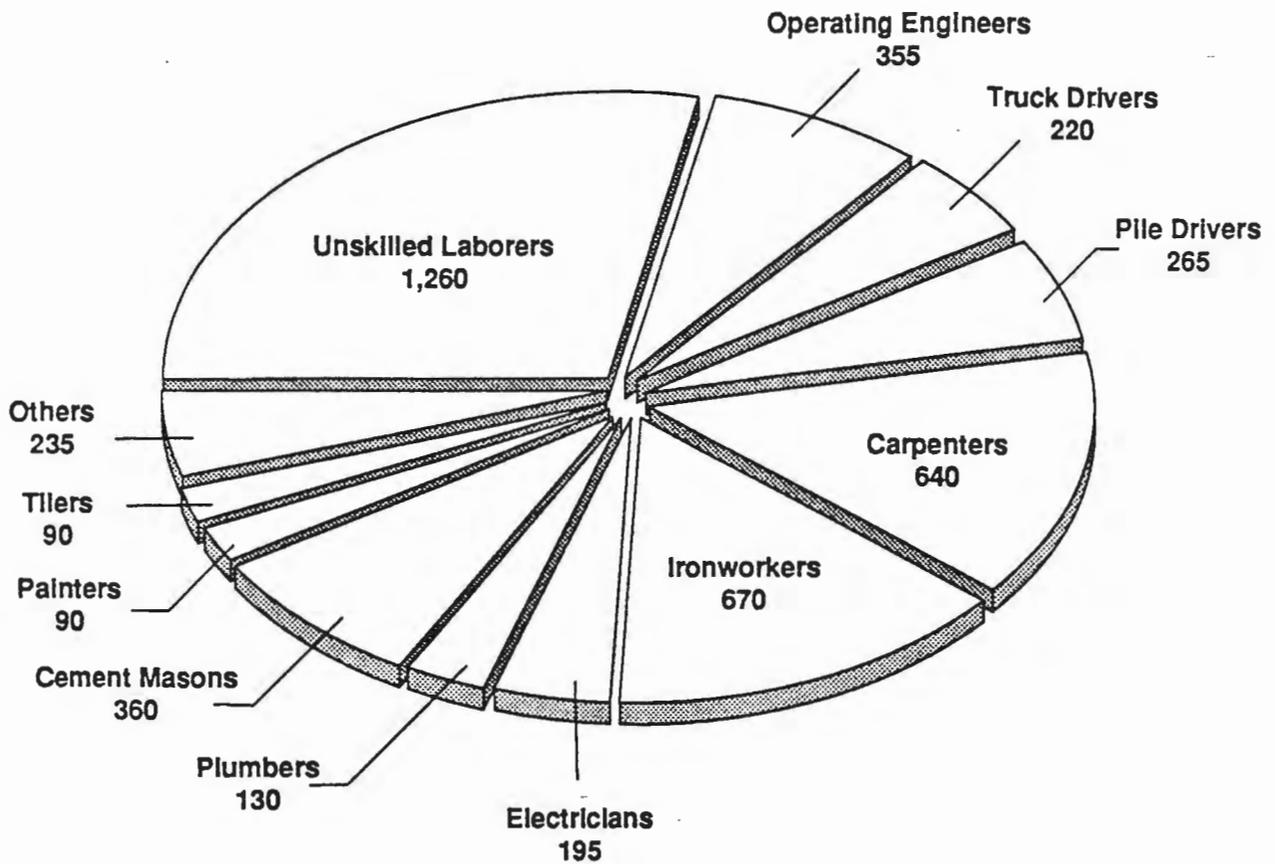
Massachusetts Highway Department
 Central Artery (I-93) / Tunnel (I-90) Project



TAB 1

APPENDIX 4

Employment projections.



Number of Full-Time Equivalent Jobs
(Peak Year: 4,500)

FIGURE

3.2

Peak Year Construction Employment

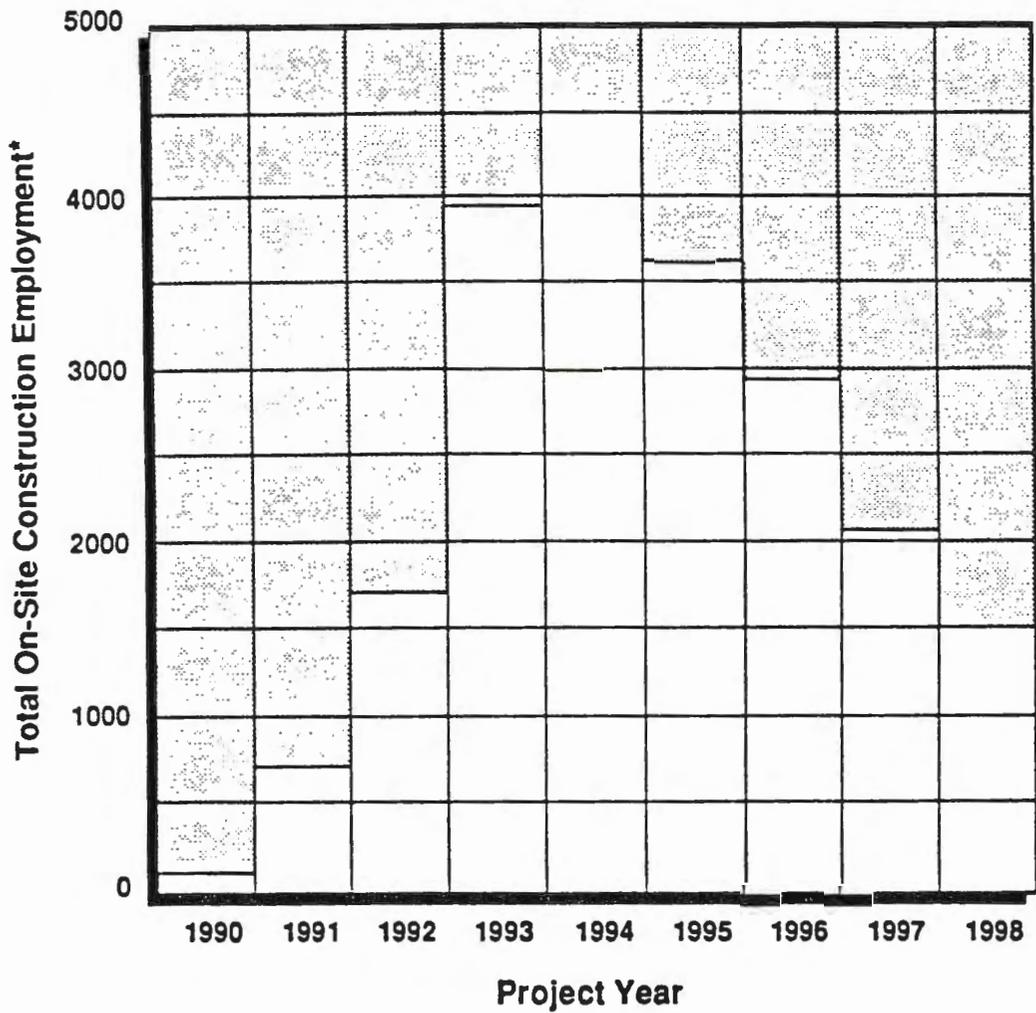
THE COMMONWEALTH OF MASSACHUSETTS DEPARTMENT OF PUBLIC WORKS
CENTRAL ARTERY (I-93)/TUNNEL (I-90) PROJECT
SUPPLEMENTAL EIS/R



Table 6**CONSTRUCTION EMPLOYMENT
FOR THE ARTERY/TUNNEL PROJECT**

Occupation	Number of Full-Time Equivalent Jobs	
	Peak Year	Annual Average
Unskilled Laborers	1,260	750
Operating Engineers	355	205
Truck Drivers	220	130
Pile Drivers	265	160
Carpenters	640	375
Ironworkers	670	390
Electricians	195	105
Plumbers	130	80
Pipe Fitters	45	25
Cement Masons	360	205
Bricklayers	45	25
Painters	90	50
Tilers	90	50
Sheet Metal Workers	45	25
Glaziers	45	25
Asbestos Workers	45	25
Total	4,500	2,100

Source: Bechtel/Parsons Brinckerhoff



* Employment is expressed in terms of full-time person-year equivalent; actual numbers of individuals will be higher.

TAB 1

APPENDIX 5

Preliminary Site Visit Report form.

PRELIMINARY SITE VISIT REPORT

Site:

Contract #

Date:

Reporter:

Prime Contractor:

Site Supervisor:

On site phone #:

ADL assigned Safety Consultant:

PRODUCTION SCHEDULE

Upcoming Jobs	Projected dates	Trades involved	Subcontractor
---------------	-----------------	-----------------	---------------

SITE CONDITIONS :

Terrain/physical conditions:

Trailer/meeting space:

Schedule of toolbox and/or mass safety meetings:

ADD NOTES ON BACK

TAB 1

APPENDIX 6

"Boston Central Artery/Harbor Tunnel Construction
Project Health and Safety Hazard Evaluation" Renewal
Application.

BOSTON CENTRAL ARTERY/HARBOR TUNNEL CONSTRUCTION PROJECT
HEALTH and SAFETY HAZARD EVALUATION

RENEWAL APPLICATION

INTRODUCTION

The principal objectives of the Central Artery/Harbor Tunnel (CA/T) Project are 1) to achieve a better understanding of safety and health hazards for construction workers on a large and multidimensional project, and 2) to prevent occupational morbidity and mortality for those doing similar types of construction work in the future. The Project is the construction of a depressed central traffic artery (the Central Artery) and a third tunnel through the Boston Harbor to Logan Airport. The CA/T Project offers a unique opportunity to study hazards for construction workers associated with excavation and road demolition/construction, with work underground and in deep trenches and on and around heavy equipment, and with work around hazardous wastes. Specific aims are 1) to characterize exposures in each phase of this variegated Project (a) by type of work done and (b) by specific trade and job category; 2) to characterize morbidity experience; and 3) to examine associated exposure-response relationships. Using industrial hygiene measurements, interviews and observation, and check-list evaluation forms, we will examine and characterize airborne and surface exposures, stress, and ergonomic risk factors for injury, accidents, and illness/disease. Detailed protocols will be developed to capture and track morbidity data from four sources: questionnaires developed on the basis of walkthrough inspections and interviews with workers and managers, medical records from health care providers, workers' compensation claims data, and OSHA 200 log forms. Exposure-response relationships will be examined in data analysis both generally by type of work and specifically by trade and job category.

The health and safety hazard evaluation of the CA/T Project is in Phase I of Year 1. Described in this renewal application are 1) tasks accomplished between October 1, 1992 and March 31, 1993; 2) work plan for April 1, 1993 to June 30, 1993; and 3) work plan for Years 2 and 3 of the Project.

TASKS ACCOMPLISHED OCTOBER 1, 1992 TO MARCH 31, 1993

During Phase I of the first year of the Project, working relationships have been established with key personnel on the CA/T construction project. These include Ken Paradis, Director of Safety/Labor Relations for Bechtel/Parsons Brinckerhoff, the Contract Manager for the project; Joseph Nigro, Secretary-Treasurer and General Agent for the Boston Building Trades

conjunction with its safety management responsibilities, ADL is collecting and tracking morbidity experience. MHD has an overall **Construction Director** and three **Area Construction Managers**. Specific work sites on the project are identified on the basis of a contract number (see Appendix 1). For each contract, there are three **B/PB Area Managers** who interface with MHD Area Construction Managers and with **Resident Engineers and Safety Managers for each prime contractor**. ADL has a Safety Consultant assigned to each contract and is presently organizing a project-wide safety committee that will include ADL Safety Consultants and Safety Managers for each contractor.

A single "wrap-up" insurer for workers' compensation has been named. This insurer, American Industrial Group (AIG), will have sole responsibility for insuring contractors on the CA/T project.

2. Detailed protocol for the capture and tracking of morbidity data from the five identified sources:

Investigation of source-specific process for the identification and tracking of morbidity data for project workers has focused to date on a) First Report of Injury Forms from the Massachusetts Department of Industrial Accidents (DIA); b) health care providers; c) information collected on-site from OSHA 200 Logs and First Aid Logs that record all minor injuries not likely to be captured by other sources; and d) information that will be collected by ADL. Because the wrap-up worker compensation carrier has only recently been named, availability and retrieval of data from this source has not been investigated yet, although the MHD has indicated their cooperation in this regard.

The DIA has agreed to work with the Project investigators to develop a mechanism of targeting and tracking First Report of Injury Forms from the CA/T project. ADL will be collecting morbidity data from site-specific logs, including OSHA and first aid logs, as well as from the worker compensation insurer. There has been agreement 1) to sharing of morbidity data by ADL and Project investigators and 2) to the use of consistent diagnostic codes [Revised Occupational Safety and Health (ROSH)] by Project investigators, ADL, and the DIA. The use of ROSH codes for workers' compensation claims will be explored with AIG, as will the use of ROSH codes for documenting "source/2nd source" of injury/illness and "event or exposure" on this construction project.

Health care providers for injured/ill workers on the project have been designated by B/PB. Those likely to be used most frequently because of their geographic proximity to the project and collective expertise are the Boston City Hospital, Winthrop Hospital, New England Baptist Hospital,

Council; G. Stewart Young, Safety Consultant for Arthur D. Little, Safety Consultant/Manager and designated worker compensation liason for the project; and the office of the Project Director for the Massachusetts Highway Department (MHD). Detailed discussions with Mr. Paradis and Donald D. White, Deputy Project Manager for Bechtel, as well as Mr. Nigro, have been necessary to gain access to the construction sites. Formal approval from the MHD is pending.

With regard to Year 1 Deliverables described in the original application, the following have been accomplished:

1. Qualitative characterization of the scope and nature of the CA/T construction project:

On the basis of information developed by the Massachusetts Highway Department (MHD) and made available to Project investigators, the CA/T project has been characterized in more specific terms with regard to scope/nature and key personnel on each job site have been identified. It involves seven miles of constructed and reconstructed roadways (see Appendix 1). Major elements are as follows:

a. Depresssion and construction of I-93 - Interstate 93 will be widened and reconstructed, mostly underground, from north of its interchange north of Charlestown to south of the Massachusetts Avenue interchange.

b. Extension of I-90 to Logan Airport - From its terminus at the Southeast Expressway, I-90 will be extended via a Seaport Access Road and the Third Harbor Tunnel to Logan Airport. There will be a connection to Route 1. An expanded high-occupancy vehicle (HOV) system will be incorporated along I-93 and I-90 to link downtown Boston at Kneeland Street and the proposed South Station Transportation Center with Logan Airport and points south and west of Boston.

c. Construction of South Boston Bypass Road - The South Boston Bypass Road will connect the Southeast Expressway directly to the Seaport Access Road and a relocated Mallport Haul Road in South Boston. Most of it will be on an existing railroad right-of-way.

d. Construction of an extended frontage road system - An extended frontage road system will be constructed parallel to I-93 northbound and southbound from Causeway Street to just past Southampton Street.

Management-Consultant Interface: The MHD has overall responsibility for the CA/T project. Bechtel/Parsons Brinckerhoff (B/PB) manages design and construction on the CA/T Project. Arthur D. Little (ADL) manages safety and acts as a liason with the workers' compensation insurer. In

Years 2 and 3 of the Project. These include CO9A1, C15A1/2, and C17A1/2.

4. Research Project Advisory Committee:

The Research Project Advisory Committee (RPAC) has been assembled and has had its first meeting. CoChairs are Kenneth Paradis, Director of Safety/Labor Relations for B/PB, and Joseph Nigro, Secretary-Treasurer of the Boston Building and Construction Trades Council. The other members are G. Stewart Young, Safety Consultant for ADL; Letitia Davis, Director of Occupational Health, Massachusetts Department of Public Health; James Merloni, Jr., Director of the New England Laborers' Training Center at Hopkinton, MA; and Priscilla Conant, Director of Claims, Massachusetts DIA. *Ex-officio* members are Project Principal Investigators L. Christine Oliver and David Wegman, and Pete Stafford of the CPWR. This Committee will provide the Project Investigators with the guidance needed to communicate effectively with and obtain cooperation from contractors and local unions on the site and to target specific sites for examination. In addition, RPAC will aid Investigators in the development and implementation of protocols for morbidity data collection and evaluation and in "trouble-shooting" when problems arise. When necessary or advisable, prime contractors and union business managers will be asked to attend RPAC meetings.

The RPAC will meet on a quarterly basis in conjunction with the Labor-Management Safety Committee meetings. CoChairs of the two committees are the same. Technical advisors to the Labor-Management Safety Committee are the *ex-officio* members of the RPAC, Laura Punnett of the University of Massachusetts Lowell, and John Moran of the Laborers Health and Safety Fund of North America.

WORK PLAN: YEAR 1 - PHASE II

During Phase II of Year 1, tasks relevant to the specified Deliverables will be completed. Specifically, the following will be accomplished:

1. Completion of job-task-exposure matrix: A preliminary walkthrough of the entire CA/T project will be carried out to allow Project investigators to obtain a better understanding of the nature and scope of the project as a whole. Then, detailed walkthrough examinations of the active contracts selected for initial evaluation will be carried out. Interviews will be done with key tradespeople and project managers to understand the nature of the potential hazards in the relevant trade activities. Data available on the materials to be encountered in the soil or the demolition phase will be collected and analyzed. Walk-thoughts will be

Tufts New England Medical Center, the Massachusetts General Hospital (MGH), the University Hospital, and the East Boston Neighborhood Health Center (EBNHC). Providers to be approached regarding participation in the Project in the remaining period of Year 1 have been identified.

3. Job-task matrix and draft sampling plan:

It has been decided to limit the Project to "horizontal" construction. A full review of the relevant literature has been completed and will be used as the basis for the construction of a trade-specific exposure matrix. Two contracts (job sites) have been targeted for on-site observation and industrial hygiene sampling in the second period of Year 1 and the early part of Year 2. These are CO4A2 and CO7A1 (see Appendix 1), two access roads to the Third Harbor Tunnel. Each has been characterized with regard to start date and duration, contractor, trades, number of workers, and type of work in a preliminary job-task matrix:

Contract #	Start-Dur Description	Contractor	Trades	Jobs
CO4A2	5/21/92 36 months Access road-tunnel	Kiewit	200 Workers Carpenters Laborers Iron workers Cement masons	Cut/cover excavation, forms, mix and pour concrete, add dirt overlay
CO7A1	7/01/92 36 months Access road-tunnel	Modern Continental	300 Workers Same	Same

Separately, work-sampling data collection forms have been developed for each trade and are ready to be piloted. Appropriate levels of job analysis and related methods have been explored and several alternatives prepared for field testing. Development of a flexible bibliographic data base is being prepared which will be continuously updated as the project proceeds. The data base is designed for easy access according to a variety of key words.

One of the Principal Investigators (LCO) has met with the ADL Safety Consultants assigned to the two access road contracts in order to inform them about the Project and to obtain their cooperation. Job-task matrices with exposures will be developed for the other contracts likely to be examined in

101 (see Appendix) for First Report of Injury will not be changed, but codes used to complete the forms will be changed to ROSH codes. AIG worker compensation claims forms and the first aid logs at each job site will be reviewed and evaluated regarding the extent to which they can be modified to capture nature and source/circumstances of injury/illness using ROSH codes. OSHA 200 Logs will not be modified.

Questionnaires will be developed to obtain baseline information about health and nonoccupational risk factors for disease and about CA/T job-related risk factors for disease and injury for the following trades: a) Laborers, b) carpenters, c) operating engineers, d) iron workers, and e) cement masons. The medical history component of the questionnaire will target musculoskeletal, respiratory, and cardiovascular systems and skin. Occupational history will be developed on the basis of a) the walkthrough of the active contract sites and b) the results of focus group meetings for hazard identification for each of the specified trades. These focus group meetings will also be used to develop a short psychosocial/stress component of the baseline questionnaire, as well as a long questionnaire to be administered separately.

Data retrieval forms will be developed for retrieval of medical diagnosis and causal circumstances by both written description and ROSH code. Input from health care providers designated by the prime contractors for contracts CO4A2 and CO7A1 will be used in developing format. These providers are Boston University Hospital/Medical Center Occupational Health Program, the MGH, EBNHC, and Winthrop Hospital.

4. Detailed protocols for capture of morbidity data from the identified sources: Protocols for administration of questionnaires and retrieval of information from the other sources will be developed as part of established working relationships with ADL and the Massachusetts DIA and Highway Department and to-be-established relationships with AIG and designated health care providers.

WORK PLAN: YEAR 2

Phase I. In the first month of Year 2, brochures will be developed to explain the aims of the research Project and describe general methods of data collection. These brochures will be distributed at all active construction [contract] sites. Those contract sites targeted for detailed evaluation will be visited by one or more investigators for on-site education about the Project and the establishment of a working relationship with the safety manager for the contractor, the line foreman, and the ADL safety consultant. OHA staff will visit each of the health care provider institutions designated by B/PB to explain the

conducted to characterize the predominant exposures present and to target those jobs that are likely to be of higher risk, for more detailed observations in Years 2 and 3.

Industrial hygiene and ergonomics questionnaire components that have been developed will be amended in response to inputs from the walk-throughs. These questionnaire components will be included in the self-administered health survey questionnaire given to workers in Years 2 and 3. The industrial hygiene questionnaire addresses the exposure potential of each trade/job task and the factors that modify potential exposures. The ergonomics questionnaire includes items on the general physical and psychosocial environment, the nature and intensity of the physical workload, and the presence and proximity of specific safety hazards. These baseline exposure data will be used to categorize jobs by severity of risk separately for musculoskeletal disorders, acute injury, and psychosocial "stress."

On the basis of these walkthroughs and review of the description of contracts to-be-bid published by the MHD, additional contracts to be targeted for detailed evaluation in Years 2 and 3 will be selected and the job-task-exposure matrix completed. Efforts are already underway to select two pairs of additional sites, each pair involving similar types of construction, for further comparisons between contractors. Each of these sites is a major, multi-million construction project. The first pair will be two sections of the submerged Central Artery (interstate highway) [C15A1/2 and C17A1/2]. We are considering, as the second pair, two sections of highway cloverleaf interchange. A third site under consideration is construction of the I-93/I-90 interchange, I-93 northbound (CO9A1). Work on this contract will involve construction of tunnels and boat sections, demolition and construction of bridges, and underpinning of railroad tracks and construction of mined tunnels.

2. Preliminary analysis of site-specific exposures and associated safety hazards: A detailed evaluation of the job site designated as contract CO4A2 will be carried using the methods described above. The predominant type of work on this contract is cut and cover excavation, using interlocking sheeting for excavation. On the basis of on-site observation and industrial hygiene sampling, a preliminary analysis of specific exposures and associated safety hazards will be carried out.
3. Development of instruments for morbidity data collection: To be developed in Phase II are a) baseline questionnaires for the capture of job-related exposure/hazard and health information and b) data forms for retrieval of medical information from health care providers serving workers on the CA/T construction sites. Format for Massachusetts DIA Forms

qualitative and semi-quantitative exposure assessment of biomechanical, physiological, and safety hazards. For example, in jobs that involve heavy lifting or other manual material handling tasks, key measurements will be made on-site to quantify weight lifted, heights lifted to and from, distances carried, and frequency and duration of tasks. The investigators' observations will be supplemented where necessary by further interviews with construction workers or their supervisors to obtain the desired information. A separate component of the ergonomics feature of this activity will be attention to psychosocial evaluation of construction trade activity. The basic Job Content Questionnaire of Karasek will be utilized to assess job strain in a series of trade-specific tasks. This will be supplemented in selected settings through the use of additional trade-specific supplementary questions selected, as appropriate, from the extended Job Content Questionnaire. This activity will be closely integrated with that of the efforts directed at critical incident evaluations being undertaken within the main study based at the MGH.

Industrial Hygiene: This phase will involve extensive on-site sampling and evaluation in combination with the questionnaire developed in Year 1. Personal air sampling will be done to investigate the exposure levels to several target agents: silica from demolition and excavation, metals and organic solvents emitted from the soils in the excavation area, airborne metal particulate produced during the demolition phase (especially lead), nitrogen oxides and polyaromatic hydrocarbons from diesel construction equipment, and airborne asbestos or fiberglass fibers released from structural applications or brake shoe particulate during the demolition phase. The sampling/analysis scheme may be altered somewhat, depending on the results of the Year 1 hazard potential. Sample results will be entered along with the exposure assessment questionnaire data into a database for statistical analysis of the factors affecting exposure levels.

Psychosocial/stress: On the basis of the first walkthrough evaluation and the results of the focus group meetings, a stratified sample of construction workers on the targeted construction sites will be selected for 45-minute semistructured interviews. The information obtained will allow the development and testing in Years 2 and 3 of specific hypotheses related to two areas of investigation: 1) the extent to which psychosocial variables and stress contribute to accidents and injury and 2) the extent to which these variables influence return to work following an accident or injury. The first will likely be a case-control study design and the latter, a follow-up study. Variables to be examined include level of worker autonomy at the work site, managerial style of the contractor(s), level and style of union involvement, workload, boredom, marital status, and substance use/abuse.

Project, enlist cooperation, and review the protocols for data retrieval. Those institutions designated for contracts CO4A2 and CO7A1 will be contacted first. Protocol reviews will be carried out by OHA staff at the DIA and the on-site office of AIG. Written educational materials appropriate for each site will be developed and distributed.

Phase II: Characterization of Morbidity Experience. In Phase II (months 2 - 12) of Year 2, a cross-sectional prevalence study design will be used to examine and characterize morbidity experience for workers on the CA/T project. For workers on the sites selected for detailed evaluation, morbidity data from each of the five sources described above will be collected and analyzed. It is estimated that this group of workers (contracts CO4A2, CO7A1) will number 450 to 500 in the first three months of Year 2. Questionnaires will be self-administered and reviewed by a trained interviewer. Attached to each questionnaire will be a consent/release form to allow investigators to obtain medical information from health care providers. The site of administration (work-site vs local union hall) will be determined on the basis of advice from the RPAC and from local union business managers and contractors. For all other CA/T workers, data from three sources will be collected and analyzed: First Report of Injury from the DIA, workers' compensation claims filed with AIG, and OSHA 200 and First Aid logs.

Self-addressed stamped envelopes will be provided to the Emergency Wards of the health care institutions for retrieval of data forms on all CA/T workers seen on a weekly basis. The Emergency Wards and the DIA will be visited by OHA staff on a biweekly basis for the first three months and less often thereafter to assess compliance with the protocol and answer questions. The telephone number of the OHA office will be made available to 1) construction workers and targeted construction site staff, 2) health care providers, and 3) DIA and AIG staff so that questions can be answered as they arise.

The feasibility of identifying and following a cohort of workers through the local unions and/or contractors will be determined on the basis of focus group meetings in Year 1 and discussions with local union officials and contractors. If worker mobility does not preclude follow-up over time, those workers who complete baseline questionnaires will receive follow-up questionnaires 12 months after completion of the initial questionnaire. From this group, subsets will be selected for 45-minute interviews directed at stress and psychosocial risk factors for construction-related injury/accidents and disease.

Phase II: Characterization of the Exposures of Trade/Job Task Combinations. **Ergonomics:** A structured, checklist-type evaluation form will be developed to facilitate standardized

TAB 1

APPENDIX 7

Summary: Group discussions with roofers in Springfield, Massachusetts.

WORK PLAN: YEAR 3

Exposure and morbidity data collection will begin in Year 2 and continue through the first six to eight months of Year 3. Data collected will be computer-entered as it is collected. Exposure data will be analyzed on a group basis by 1) trade, 2) job task, 3) type of work, and 4) contractor. Detailed morbidity information will be collected on a subset of the total workforce. Those individuals who complete the baseline and follow-up questionnaires will be asked to sign consent and release forms that will allow investigators to access medical records and worker compensation claims data by name. This information will allow analysis of exposure-response variables on an individual as well as group basis. It will also allow the tracking of morbidity experience over time to evaluate the development of chronic disease in association with acute work-related injury/illness and to evaluate effects of work-site intervention. Each participant will be identified by a specific ID number for purposes of data analysis. The master list of names-ID numbers will be kept in a locked medical file in the office of OHA to ensure confidentiality.

Data analysis will begin in Year 2 and be completed in Year 3. In addition to characterization of morbidity and exposure-response relationships, sources of morbidity information will be examined with regard to accuracy and compared with regard to consistency. The extent to which data retrieval information from proximate health care providers can be regarded as the "truth" with regard to medical diagnosis will be investigated and used to judge accuracy of other reporting forms. The extent to which ROSH codes capture and accurately reflect construction exposures/incidents, as well as diagnosis, will also be examined. Based on preliminary analysis of exposures and health outcome variables, more specific hypotheses regarding exposure-response relationships will be developed and tested. Of interest, for example, is the occurrence of acute and chronic airways disease in these construction workers and possible causal exposures.

Summary of interview with roofers, Springfield, 3/27/93

Following an introduction to the language and concepts of ergonomics, ten roofers sat around the table for a discussion. Only 4-5 participated. The remainder were interested but not active. The discussion focused on which risk factors occurred on which jobs. At first, the response was that all parts of roofing are hazardous. But as the risk factors were listed one by one, the workers were able to identify the jobs that they thought were the most hazardous:

Heavy lifting: Single ply and lumber work are the heaviest. Rolls of rubber used to come with a machine to roll them out. Hand trucks often break. They speculated that there was a weight limit in their collective bargaining agreement. Someone went and got a copy and there is a 65 lb limit on roofing paper. They agreed that it is seldom enforced.

Awkward postures: Parapet walls, duct work often involve bending and twisting.

Repetitive motions: Using screw guns, whether using them in a bent-over posture or while kneeling.

Uneven/slippery surfaces: Bad housekeeping, trash on site, moving over or among stock, puddles, standing water. Several workers told a story of a site which had to be entered by going up a makeshift ramp that was icy in the winter.

Badly designed tools: Screw guns are uncomfortable. They estimated that they do 2000-4000 screws per day. They felt that the older tools were better designed and lasted longer.

The group was mixed-apprentices and journeylevel. They agreed that on the job older workers seldom show younger workers how to do things. People learn by watching and often get sprains and strains in the process.

A couple of the workers had had experience with stand-up screw guns, but they complained that they jam. The fear was expressed (again) that changes in technology which reduce ergonomic hazards might result in a loss of jobs. One worker said that he would rather work hurt than not work at all.

These workers also expressed concern over blatant disregard by some contractors for minimum safety precautions, such as fall protection and personal protective equipment. They said that the recession had made the industry more competitive and less safe.

TAB 1

APPENDIX 8

Summary: Conversation with Julian DuPont, Ironworker.

Conversation with Julian DuPont, Ironworkers, Local 357

Mr. DuPont is a 45 year old Ironworker with 29 years in the trade. He is a teacher in the union apprenticeship program and is conducting a 5 session course on health and safety for union Ironworkers and Roofers in western Massachusetts. He has a musculoskeletal disorder himself, a separated tendon of the forearm. I spoke to him on March 17, 1993, in preparation for assisting him, and Phil Korman of Western MassCOSH, in a class on Repetitive Motion Injuries. We had a long and enjoyable conversation about Ironwork. He provided the following information.

He identified at least eight jobs within the trade: rebar ("rod work"), structural, ornamental, decking, bolting up, curtain wall, windows and welding. He said that an Ironworker needs to know all these jobs and might have to do any one of them but that when a worker gets on a specific site, he [I will use "he" in this instance because the local has no women members] will generally stay working at the same job for the length of the project. This seemed particularly true on a "story job" where the workers move up with the building's construction. He said that there is some level of specialization and that he felt that workers specialized more as they got older. We spoke briefly of welding and he pointed out two hazards. The traditional way of pushing down a welding helmet is to shake it down with a flick of the neck. He knows of workers who have suffered cumulative trauma to the neck as a result of this practice. He also said that as welding with rods has been replaced by a continuous coil, the work has become more repetitious and tedious.

We broke rebar work ("rodbusting") down into two parts: sorting and installing. Sorting involves walking among or on top of piles of rebar in the lay down yard. The rebar has been cut prefab off site (and non-union) to spec, is tagged and delivered and stockpiled on site. The workers, often in pairs as partners, climb on and pick through the stock until they find the pieces that are needed. This involves walking on uneven and slippery surfaces, awkward postures, repetition and lifting. When they have sorted out the needed stock and dug it out of the piles, they carry it to the location of installation. This involves heavy lifting. The installation is composed of placing the rebar, feeding and tying it in place. This involves bending over for extended periods, forceful exertions and repetitive motions with the

TAB 1

APPENDIX 9

Ergonomic exposure audit checklist.

hands. Mr DuPont's opinion is that bridge work is the most hazardous type of Ironwork.

He said that his method of dealing with the musculo-skeletal stress and strain, and the one he teaches to apprentices is, "Work steady and comfortably and don't lift more than you can handle." He feels that the depressed economy has caused the industry to "go backwards" on safety. In order to reach unrealistic job completion schedules, the pace is faster and there is too much overtime. He feels that a worker is too tired to work safe after the ninth hour in a day. He said that, with speed up, the contractors stockpile too much material on site causing cluttered and confined spaces and causing workers to do more lifting when sorting stock. He suggested setting stock limit standards specific to different types and size sites. He himself has learned to use the computer master lists for rebar stock in order to save manual effort in rebar sorting and he promotes this practice but said that it is not widely used.

He was critical of contractor safety programs which give workers jackets or cash bonuses for reaching "Work Safe" targets because they result in under-reporting of hazards. He was also cynical about the contractors commitment to health and safety saying that "they play dumb" and fail to comply with what is already mandated. He pointed out that he had invited 26 contractors to the course that he is teaching and none of them have shown up.

We talked about the macho culture of construction and the prevailing attitude that a worker with a musculoskeletal disorder is a baby (Foreman says, "This is a construction site. You can't cut it, go be a bag boy.") Mr. DuPont felt that training could make a change. Apprentices and foremen should receive training in repetitive motion injuries and upgrade training should be provided for all workers. He also said that workers should be trained to get hazards on the record by raising them at safety meetings. He said that the situation will probably not change immediately but a record would provide a basis for union action.

Susan Moir, University of Mass./Lowell, 29 March 1993

WORK ENVIRONMENT

Department of Work Environment
University of Massachusetts Lowell
Central Artery/Tunnel Ergonomics Project
Hazard Identification Working Group

ERGONOMIC EXPOSURE AUDIT ITEMS / CHECKLIST

LIFTING EXCESSIVE WEIGHTS

- Are heavy objects labeled by weight?
- Are contractual weight limits posted?

AWKWARD POSTURES

UPPER EXTREMITY

- Working with bent wrist
- Reaching above the shoulder

TRUNK

- Kneeling
- Squatting
- Stooping/bending
- Twisting

REPETITIVE MOTIONS

POWER TOOLS

- Vibration
- Heavy, unbalanced load
- Recoil/impact
- Trigger design

HOUSEKEEPING

- Adequate lighting
- Walking/climbing on stockpiled materials



TAB 1

APPENDIX 10

Summary: Meeting with ADL consultants.

Summary of meeting with Arthur D. Little Consultants April 7, 1993

Bryan and I met with eighteen people at ADL. Twelve were employees of ADL, including one IH, one statistician, seven marine specialists and three safety consultants. Three were safety consultants employed by Alpha, an ADL subcontractor. Two were Safety personnel from Kiewit, a contractor on the project. The eighteenth was project director Stewart Young. About half of the group had experience doing construction work. About half raised their hands when asked if they knew what ergonomics was. But they were reticent when asked what it was. They answered with the first law, "Fit the job..."

I went through the draft of the basic training very quickly. As I was doing it I felt that, at least for this group, it was weighted too much to health effects and not enough to risk factors.

They responded affirmatively to the question of whether they see ergonomic hazards on site. They immediately identified pipe-jacking, electrical pipe bending, working in an on-site carpentry shop and operating heavy equipment as ergonomically hazardous. They challenged our idea that tunnel work is too mechanized to present many problems. They said that there is a lot of finish work in the Third Harbor Tunnel and that it is very repetitive. In fact, they said, the industry is repetitive because, although the work moves from site to site the worker is doing the same thing over and over.

They agreed that the work organization is a problem and told horror stories about workers going until they dropped. The marine specialists pointed out that when the site is ready for their work, it has to be done at great speed until it is finished.

Our four prioritized contracts were called into question when they said that the Tunnel is hazardous and that the South Boston haul road was not labor intensive. But they also said that the rate of work has been low due to the weather and would be picking up.

They were mixed on back belts, but the pro-belt faction was the most vehement and had their references ready: "Check out Walmart."

TAB 1

APPENDIX 11

Discussion group questionnaire.

Aside from back belts (which was mild in comparison) three areas of controversy arose: the proposed OSHA ergonomic standard and its applicability to construction work, incentive bonuses within safety programs and workers compensation. Some strong opinion where expressed that construction should be excluded from the proposed OSHA standard. There was strong (although not universal) support for cash and material incentive bonuses for safety. Incentives (caps, jackets and cash) are a part of both ADL's and Kiewit's strategies. There was considerable opinion which blamed the worker for high workers compensation rates. Again, (this came up with the Roofers in western Mass.) people raised the problem that the contractor who gets the claim for a cumulative trauma disorder takes the entire financial hit even though the injury occurred over a period of time when the injured worker probably worked for many contractors. Another important point that was made was the allegation that workers comp becomes a form of unemployment insurance in an industry that is so unstable. Is this true?

We finished with a discussion of their field program. It is very individualized by consultant. Although they are working towards a standardized method, they were unwilling to share that with us. Safety meetings do happen at the sites, at least once a week, sometimes more often. Sometimes they are by crew, sometimes mass meetings. At least for Kiewit, there is a trailer where mass meetings can be conducted. They seemed open to the possibilities of us being at those meetings. We gave them our Ergonomics Checklist. After the meeting Stu Young said that they would try to integrate it into their data collection. A problem is that only regulatory violations are included in their compilations. Stu said that he would work on this, but we probably want to come up with some suggestions.

Good first meeting.
5/5/93

Susan Moir

TAB 1

APPENDIX 12

Introduction to focus group meetings.

Today's date:

Discussion Group questionnaire

Thank you for joining us. The information that you give us today will help in improving the health conditions for unionized construction workers on the Central Artery/Tunnel project. In order to make the most of this information we ask that you answer the following questions. All information will be kept confidential.

Name: _____

Address: _____

Phone: _____

Age: _____ Trade: _____

Union: _____ Local: _____

Years in the trade: _____

Describe what you do during the day: _____

Have you ever had a work related **sprain or strain** injury? yes no

What part of your body was injured? _____

How did the injury happen? _____

Please briefly describe your work history. What jobs have you done in your trade and for how long? How much have you worked in the years since you entered the trade? Any other information which you feel is important to your health.

Use other side if needed.

THIS INFORMATION WILL BE KEPT STRICTLY CONFIDENTIAL

TAB 1

APPENDIX 13

Focus group script.

Introduction to Focus Group May 1993

I want to thank you for participating in this discussion group. I know that some of you might feel a little nervous about doing this. I would feel that way too. We're looking today for your ideas and feelings about a subject which each of you knows a lot about--how construction work affects your body. There are no right or wrong answers and we are not testing you. We just want to know what you think. If someone says something that you disagree with, you can say so, and why; we will discuss the different opinions. We would like to hear from everyone in the group. Once we get started, try to talk to each other, not to me. I am here to ask the questions to get you started on several topics. We would like you all to have a conversation on each of the subjects.

We will be doing many groups like this with construction workers on the Central Artery/Tunnel Project. We hope that giving us a chance to hear what you know will make the work that that we do much more relevant and useful to the work that you do. We want to assure you that anything you say will be held strictly confidential. We hope to use what you say, but we will never use your name or other information which would identify you.

To begin, why don't we go around the room and identify ourselves so that the people who listen to the tape will get to know our voices. I'll start. I'm _____ and I'm from the University of Massachusetts at Lowell. I work as a researcher on the Central Artery/Tunnel Project at the Work Environment Department.

Revised Focus Group Script
May 1993

[Following welcome introduction.]

First, we would like to ask you if you are familiar with this term.

WORK-RELATED MUSCULOSKELETAL DISORDERS? [Display
Storyboard #1.]

What does this term make you think of? Do you know what it means?

Do you have any WORK-RELATED MUSCULOSKELETAL DISORDERS?
What are they?

Here is a map of the human body [Display Storyboard #2.] I'm going to pass
out copies of this picture to each of you and I would like you to mark
on it any place that you have musculoskeletal aches and pains? Could
you also please fill in your trade, years working at your trade and your
age?

These are some of what are called RISK FACTORS for "work related
musculoskeletal disorders. [Display Storyboard #3.] We would like to
know about the jobs that you do which involve these RISK FACTORS.

Let's start with REPETITION. What are the things that you do that are
repetitive? [Make a list on newsprint.]

Next, let's talk about AWKWARD POSTURES. By this we mean such things
as BENDING, TWISTING and REACHING. What jobs do you do
which involve AWKWARD POSTURES? Can you think of other
AWKWARD POSTURES?

TAB 1

APPENDIX 14

Pain body map.

Now let's talk about NO REST. Are there jobs which do not allow you the rest that your body needs? What about overtime?

The last RISK FACTOR we want to talk about today is HEAVY LIFTING. We know that construction work involves a lot of heavy work. Can you talk about the specific jobs that involve the heaviest labor?

We would like to show you this word: ERGONOMICS? [Display Storyboard #4.]

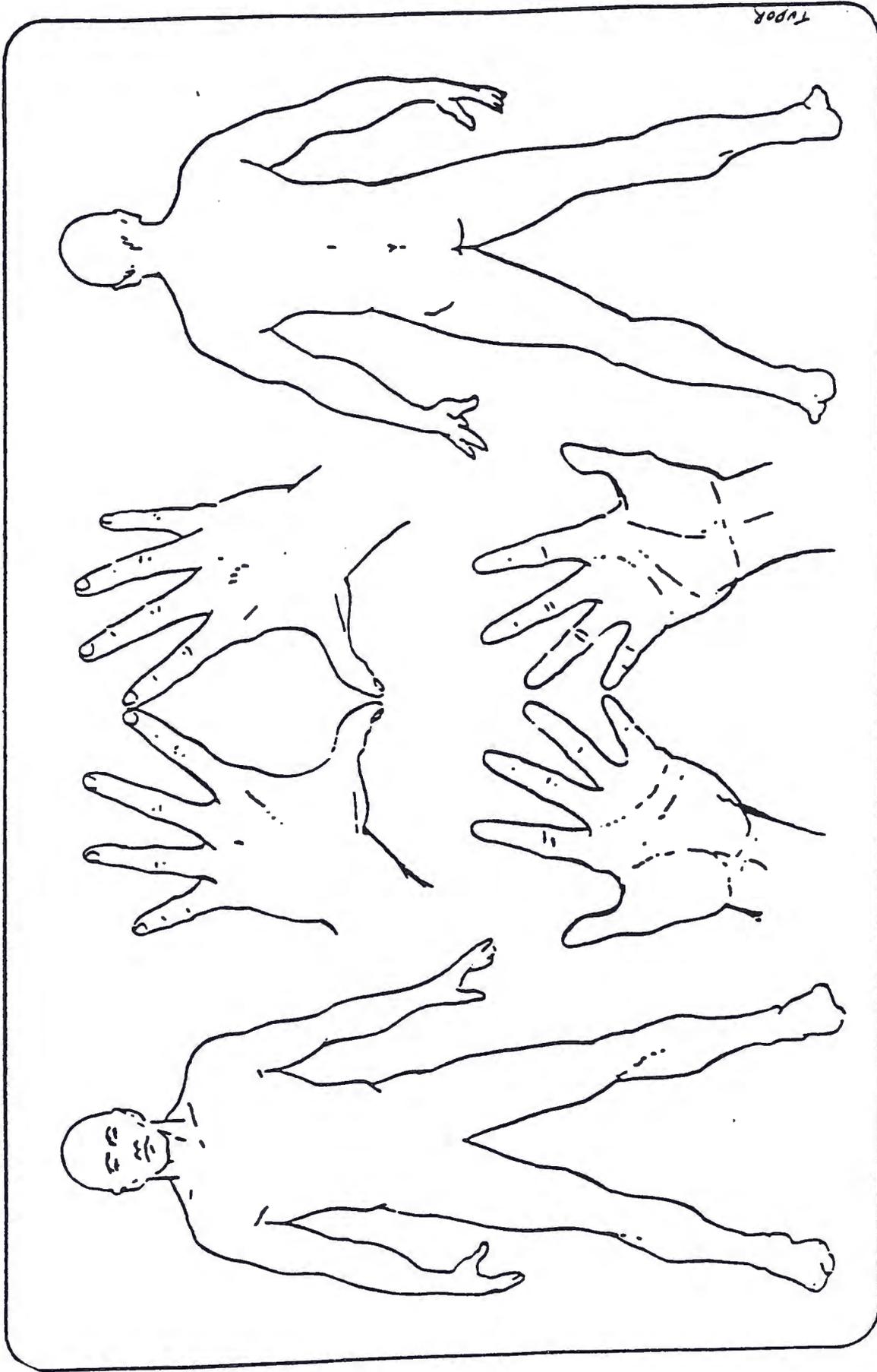
Do you know the meaning of this word? What does it make you think of?

We have been discussing ERGONOMICS today. It is the science of tool and work design and the effect on the worker's body. We have talked about RISK FACTORS, the causes of WORK-RELATED MUSCULOSKELETAL DISORDERS. And we talked about the aches and pains that you suffer as a result of the RISK FACTORS. The guiding principle of ERGONOMICS is: "Fit the job to the worker, not the worker to the job. [Display Storyboard# 5].

Often workers make CHANGES at work without knowing these terms that we have talked about today. Can you think of changes that you have made or that you have seen someone else make in order to reduce the risk of musculoskeletal injury? [Make a list on newsprint.]

That is all the time that we have today. The overall goal of our research project is to come up with as many ways as possible to make construction work better for the people who do it. Your help is essential to attaining that goal. Thank you very much for coming and for helping us with this project. [Give out brochures and make short pitch for program. Encourage participants to call with questions and ideas. Take any final questions.]

Where do you have pain in your body?



TAB 1

APPENDIX 15

Key words for computerized bibliography of ergonomic construction hazards and controls.

KEYWORDS

For computerized bibliography or ergonomic construction hazards and controls

Back disorders	Material handling
Bricklayers	Musculoskeletal disorders
Carpetlayers	Overhead work
Concrete workers	Operating engineers
Construction workers	Postures
Epidemiology	Painting
Electricians	Roofing
Fatigue	Scaffolding
Hand tools	Sheet metal work
Hazard ID	Training
Injury prevention	Hand/arm vibration
Ironworkers	Whole body vibration
Knee disorders	Work analysis method

TAB 1

APPENDIX 16

PATH method description.

"PATH": A modified work sampling-based approach to ergonomic job analysis for construction work

Introduction

"Non-repetitive" work may mean that there is no regularly repeated cycle of tasks or work elements in the job to be analyzed. Alternatively, it may mean that there is a cycle which is long, which is variable in its total duration and/or its content (the number or sequence of steps that comprise it), or which accounts for a smaller proportion of the total work performed by an individual within that job title.

In any of these situations, it is not simple to select the appropriate strategy for quantifying the duration of time spent in various tasks and exposed to various ergonomic (or other health and safety) hazards. Obviously, when there is no work cycle at all, any method based on continuous description of the cycle elements, their duration, and their hazards is impossible to utilize. If there is a cycle that is long and irregular, a very large number of cycles may need to be recorded in order to quantify accurately the total and average duration of exposures.

One alternative to work cycle-based job analysis is that of work sampling. A rigorous work sampling protocol involves observation of the tasks performed at randomly selected intervals, with pre-determined categories of tasks or hazards to be observed. Statistical power calculations are used to determine the total number of observations to be made. As a further refinement, stratified sampling may be performed when work content, work load, or exposures are known in advance to vary over time, either routinely (e.g. Monday and Friday versus mid-week) or according to non-routine factors (e.g. weather).

In our assessment of ergonomic hazards involved in heavy and highway construction, we began with the overall observation that construction work was quite low on the continuum of repetitiveness and generally had no definable work cycles. A job analysis strategy based on work sampling therefore seemed appropriate. We assumed that the non-cyclic nature of the work would permit the use of fixed-interval sampling without great risk of bias in the results.

However, because of the varied nature of the work, we believed that the stage of the construction process might influence the frequency and intensity of exposure to various ergonomic stressors; also, these certainly needed to be documented for each operation individually. "Blind" sampling without regard to stages, operations and tasks would not permit generalization of our results to other construction sites and workers. It would be necessary to collect the sampled observations for each trade within definable stages and operations.

Therefore as a prelude to job analysis, the hierarchical taxonomy used by the Massachusetts Highway Department has been adapted for use on this project to describe the process of highway construction. The construction process is first broken into stages, which may include: earthworks, tunneling, drainage, sub-base/pavements, structures and

utilities. Each stage is divided into several operations, e.g. earthworks may include: clear and grub, excavation, screeding and pile driving. Each operation is further separated into tasks and the trade involved in each task is identified.

Method

The first step in our job analysis strategy then is to determine the stage of the construction process underway at a particular site and the operations being performed. A description of the tasks in each operation is used to identify the activities performed in each operation by each trade. A narrative of each operation is obtained from supervisors and workers on-site. Sampled observations are then made within strata defined by these operations and tasks.

As our knowledge of construction work has evolved, we have learned that much of the construction process is cyclical, though not necessarily highly repetitive. For example, in the operation pipe laying within the stage drainage, a number of sections of pipe will be fit together. The tasks involved as each section of pipe is fit into the previous section are basically the same, although each individual worker may actually do different tasks and a given worker may be called to a different operation. To avoid biasing results, the individual workers to be observed and the duration of observation for each are decided in advance (rather than on the basis of what they do when we are on site).

Since we wished to document both the relative frequency of various tasks and a broad range of ergonomic exposures, we developed an observational checklist that we have called PATH for Posture, Activity, Tools and Handling analysis. PATH is a work sampling-based method which takes real-time observations of workers at a specified frequency. The maximum sampling frequency is approximately two per minute. Instantaneous posture information was recorded using a coding system for four major body parts [a modification of the Ovako Working Posture Analysing System (OWAS)]. Tasks/activities, tools/equipment, and type of handling data are collected on a checklist developed for a specific trade and operation.

Data analysis provides information which can be used to quantify exposures such as: percentage of work time spent performing specific tasks and in at-risk postures, overall and subdivided by type of grasp or tool used. Results can be used to describe the ergonomic stressors presented in specific construction processes and operations, and to target tasks for more detailed analyses. Duplicate real-time coding was performed by a second observer and by the original observer using videotape, to examine reproducibility of the results. This reliability has been further compared between body parts and between trades.

Pilot Work

The following is a description of the progress made as of 10-31-93 in the development of the Posture Activity Tools Handling (PATH) analysis method. On 5 occasions, over the course of six weeks, the project coordinator and two research assistants have visited a union highway construction site on routes 3 and 44 in Plymouth, Massachusetts. Video and

PATH data have been collected from laborers and operating engineers during the Drainage operations of laying pipe, installing catch basins and manholes, and rip rap (laying rocks in the outflow from pipe drainage system); the Earthworks operations of excavating, grading, screeding, screening, and compacting; Structure Demolition operation; and Sub-base and Pavements operation of road widening. To date, 818 samples of PATH data have been coded in a data base (Excel 4.1 Worksheet).

During the first several visits, the research assistants examined the same subjects simultaneously so that estimates of inter-observer reliability could be obtained. Initially four subjects were examined for two fifteen minute periods each, and samples were taken at 45-second intervals. Eighty samples were recorded for laborers, and 74 samples were recorded for operating engineers in this manner. Obstructed views were not included in the determination of inter-observer reliability. Overall, inter-observer reliabilities for each posture were high (trunk: .89, neck/head: .64, legs: .90, and arms: .99). Inter-observer reliabilities for the postures of laborers were generally lower (trunk: .82, neck/head: .54, legs: .81, arms: .99). Inter-rater reliabilities improved for observations of laborers on subsequent visits (trunk: .86, neck/head: .76, legs: .89, arms: .99). Although the inter-observer reliabilities for the coded trunk and head/neck posture of laborers were not extremely high, the frequency of the different trunk and neck/head postures was very similar for each observer. Difficulties appear to be related to observers not doing the analysis in the exact same "instant" and disagreement on angles near the cutoff for a code. It was decided that inter-observer differences would not improve much, so after the second site visit, the researchers recorded data separately. The number of samples recorded during each operation for each trade and task are summarized in Table 1.

Table 1. Samples collected as of 10-31-93.

Stage	Operation	Trade	No. of Samples
Drainage	Laying Pipe	Laborers	175
Drainage	Laying Pipe	OE	95
Drainage	Catch Basins/Manholes	Laborers	80
Drainage	Rip Rap	Laborers	348
Earthworks	Structure Demolition	OE: Oiler	40
Sub-base/Pavements	Road Widening	Laborers	80
Total:			818

The initial posture assessment indicates that both operating engineers and laborers spend a large percentage of time in awkward postures. It appears that some operating engineers may spend as much as 50% of their time with their necks rotated 45 degrees or more. This neck rotation may be associated with driving machinery backward, but may also occur (although less frequently) while the operating engineers drive forward or operate the machine's tools. While performing a task such as shoveling, it appears that laborers may spend over 60% of their time stooped and twisted, and up to 40% of their time with their necks rotated. These initial posture estimates indicate a need for further study of the awkward postures of laborers and operating engineers during various job tasks. More data

are being collected to clarify the proportion of time that operating engineers and laborers spend in awkward postures during different highway construction tasks.

Over the past several weeks, it has become apparent that the PATH assessment technique (specifically the OWAS posture categories) is not sensitive to the repetitive hand and arm movements observed in some operating engineers. The frequency of handling controls and subtle motions of shoulder rotation can not be captured with the PATH method. One example of a task, in which this is apparent occurs during the pipe laying operation while an operating engineer rocks the two joystick controls of an excavator that control the machine's bucket. These controls are located below shoulder height and therefore the OWAS arm code recorded during the task is always 1 (both arms below shoulder height). The closed cabs and relatively large travel distances observed during some machine operations also inhibit observer visibility.

Alternative observational methods are currently being sought which will allow researchers to estimate the number of control movements during an operating engineers' tasks. The feasibility of mounting a video camera behind the operating engineer, aimed at a wide angle fish-eye mirror mounted in front of and above the operating engineer, is currently being tested. Such a video tape could be used to record the number of hand and foot movements while the operating engineer performs the tasks. A method similar to Keyserling's simulated real-time posture analysis method could be used to analyze the videotape.

Electrogoniometers are also being tested as a method for assessing repetitive arm motions of operating engineers. One concern here is filtering out extraneous arm movements such as head scratching.

Record Keeping

The data base used to store the information is an Excel 4.1 Worksheet for the Macintosh. Included in the data base are: observation number, record number, trade and initials of observed subject, trunk code (1-4), head code (1-3), leg code (1-10), arm code (1-3), task performed, number of hands used to perform task, grasp type, tools used, estimated external load on hands, and the construction stage and operation. Coded abbreviations have been assigned to the tasks, number of hands used, and grasp used to facilitate the data management process (see Key Words for Spread Sheet). This data management system allows data to be manipulated in a multitude of ways, and will be of great assistance in the data analysis phase of our project. The data analysis permits quantification of exposures such as: percentage of time workers spend in awkward postures during specific job tasks or operations, tools associated with awkward postures, and estimated external load on the hands during job tasks. Results can be used to target tasks for more detailed analysis.

TAB 1

APPENDIX 17

Work sampling form.

TAB 1

APPENDIX 18

Work sampling form cover sheet.

Date:

Record Numbers: _____

OPERATION COVER SHEET

Job site:

Contractor/ subcontractor:

Contact person at site:

Stage of work project and brief description of what is involved:

Projected length of work stage, operation:

Physical conditions (temperature, rain, muddy, noise, etc.):

trade	names and initials	description: color hat, clothes, height, weight	trade yrs.	PPE?

Union local:

Tools and materials	weights

Number of people on crew ____. Performing of same or complementary tasks? describe.

Approximate viewing distance away from worker(s), viewing from well above worker? below? about the same height ? Mainly from behind, in front?

TAB 1

APPENDIX 19

Modified OWAS posture chart.

Table 1: Modified Posture Codes

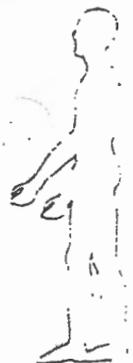
<u>BODY PART</u>	<u>POSTURE CODE</u>	<u>DESCRIPTION</u>
Trunk	1	Trunk is neutral or straight
	2A	Trunk is bent forward 20° - 45°
	2B	Trunk is bent forward > 45°
	3	Trunk is laterally bent or is straight but rotated > 20°
	4	Trunk is bent forward > 20° AND is rotated
Head and Neck	1	Head/neck vertical < 30° flexion or extension AND <45° of rotation
	1r	Head/neck vertical < 30° flexion or extension AND ≥45° of rotation
	2	Head/neck flexed > 30° with any combination < 45° of rotation OR head/neck laterally flexed > 20°
	3	Head/neck extended > 30° with any combination < 45° of rotation
Legs	1	Standing with both legs straight
	2	Standing with 1 leg in the air
	3	Standing with both knees bent > 30°
	4	Squatting
	5	Walking/moving
	6	Kneeling on 1 or 2 knees
	7	Sitting on a chair
	8	Sitting on the floor
	9	Crawling (moving on knees)
	10	Legs not supporting the body
Arms	1	Both hands down (elbows below shoulder level)
	2	One elbow ≥ shoulder level, one elbow below
	3	elbows ≥ shoulder level

TAB 1

APPENDIX 20

Example PATH data.

TRUNK



(1) straight



(2A) bent forward 20-45°



(2B) bent forward >45°



(3) straight & twisted lateral bent



(4) bent >20° & twisted

HEAD and NECK



(1) vertical no turning



(2) bent forward >30°



(3) bent to side >20°



(4) turned >30°



(5) bent back



(6) bent & twisted

LEGS



(1) standing 2 knees straight



(2) standing 1 leg in air



(3) standing with 1 or 2 knees bent >35°



(4) squatting



(5) walking/moving



(6) kneeling on 1 or 2 knees



(7) sitting on the chair



(8) sitting on the floor



(9) crawling (moving on knees)



(10) legs are not supporting body

ARMS



(1) both arms down



(2) 1 arm above the shoulder



(3) 2 arms above the shoulder

Trunk Postures during Rip Rap Operation

Overall (2 workers, 2 days)

Posture	n	P	(90% CI)
1	134	.405	(.316, .494)
2a	13	.039	(.004, .074)
2b	21	.063	(.019, .107)
3	9	.027	(-.002, .056)
4	154	.465	(.375, .555)
N = 331			

DS (2 days)

Posture	n	P	(90% CI)
1	55	.567	(.401, .733)
2a	6	.062	(-.019, .143)
2b	5	.052	(-.022, .126)
3	3	.031	(-.027, .089)
4	28	.289	(.137, .441)
N = 97			

LP (2 days)

Posture	n	P	(90% CI)
1	79	.338	(.236, .440)
2a	7	.030	(-.007, .067)
2b	16	.068	(.014, .122)
3	36	.026	(-.008, .060)
4	126	.538	(.430, .646)
N = 234			

LP (10/19/93)

Posture	n	P	(90% CI)
1	26	.250	(.110, .390)
2a	6	.043	(-.023, .109)
2b	10	.096	(.001, .191)
3	0	.000	(.000, .000)
4	62	.596	(.437, .755)
N = 104			

LP (10/26/93)

Posture	n	P	(90% CI)
1	53	.408	(.266, .550)
2a	3	.023	(-.020, .066)
2b	5	.038	(-.017, .093)
3	6	.046	(-.015, .107)
4	63	.485	(.340, .630)
N = 130			

TAB 1

APPENDIX 21

Hierarchical taxonomy of construction process.

HIGHWAY CONSTRUCTION STAGES

STAGES	OPERATIONS	TASKS	TRADES
Earthworks	Clear and grub Excavation Processing Grading Clearing debris Screeding Sheet pile/pile driving Tie backs Caissons Soil mix wall		
Tunneling	Cut and cover Immersed tubes Cofferdam Dredging		
Drainage	Pipe laying Catchbasins/manholes Lagging Soldier pile Rip rap		
Water systems			
Sub-base/pavements	Base slab Mud mat Waterproofing Mesh		
Curb Highway guards/walls Incidental work Structures	Bridges Vent buildings Pump stations Viaducts Cofferdams Slurry walls		
Utilities Demolition			

TAB 1

APPENDIX 22

Ergonomic awareness module.

**HIGHWAY CONSTRUCTION STAGES
EARTHWORKS**

OPERATION	TASK	TRADE	EXPOSURES
Clear and grub	cut & chip grub stumps remove	OE	
	manual clearing	LAB	
Excavation	scraping	OE	
	backfilling	OE	
Processing	dozing	OE	
	screening	OE	
	loading	OE	
Grading	scraping	OE	
	rolling	OE	
	manual grading	LAB	
Clearing debris	manual loading	LAB	

BASIC ERGONOMICS AWARENESS: A Core Module

**An interactive poster
presentation of the basic
terminology and concepts of
occupational ergonomics and
its applicability to
construction work.**

**"HAVE TRAINING, WILL
TRAVEL"**

WHERE?

- 1. Monthly union meetings.
(Up to several hundred workers).**
- 2. Toolbox safety meetings.
(5-15 workers in crew).**
- 3. Focus groups.
(4-8 workers).**
- 4. Anywhere we can get them.
(?#s).**

GOALS:

- 1. Introduce workers to the basic concepts of ergonomics and to empower through language.**
- 2. Use a low-tech medium adaptable to the situations where there is access.**
- 3. Not to shut the lights off.**

TAB 1

APPENDIX 23

Ergonomic storyboards.

ERGO/NOMICS

work

law

*"Fit the job to the worker,
not the worker to the job."*

Exposure to the

RISK FACTORS

for work-related musculoskeletal disorders

TRAVELS *with you for life*

TEMPERATURE EXTREMES

REPETITIVE MOTIONS

AWKWARD POSTURES

VIBRATION

EXCESSIVE FORCE

LACK OF REST TIME

STRESS

Exposure to ergonomic risk factors may result in

CUMULATIVE TRAUMA DISORDERS

(CTDs)

Low Back Injury

Tendonitis/Tenosynovitis

Carpal Tunnel Syndrome

Bursitis

Strains and Sprains

Job Analysis

MEMORANDUM

TO: Scott Schneider
FROM: Pam Susi 
SUBJECT: NIOSH Visit Dec. 15 & 16
DATE: December 9, 1993

Scott, I spoke to Doug Bower, Davis Superintendent @ the IAM reno job today. He said there should be 6-7 drywall finishers working on the 15th & 16th. They are union and we shouldn't have any problem with language barriers. He thinks they work from 7:00 to 3:30. I told him we would see him on those days.

I relayed this info to Ken Mead. The four of them plan to come in on Tuesday night. They will be staying at the Omni Shoreham (234-0700). They'll have a minivan to get to the site. I told him I would probably try to meet them at the hotel early Wednesday and go with them to Dupont Circle rather than try to meet them at the site, although we may want to revise that plan.

They are interested in getting to the NPR site as well if possible. No luck yet reaching Steve Wolford. I've also got a call into Stan Manvell to see if he can come out to meet us.

c: P. Stafford

BASIC ERGONOMICS AWARENESS: A Core Module

**An interactive poster
presentation of the basic
terminology and concepts of
occupational ergonomics and
its applicability to
construction work.**

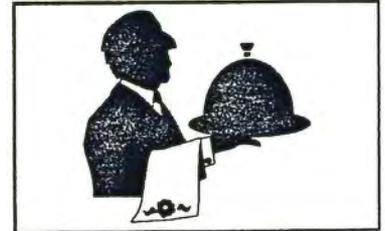
**"HAVE TRAINING, WILL
TRAVEL"**

Scott

HOLIDAY LUNCHEON

WASHINGTON COURT HOTEL
MOUNT VERNON ROOM
DECEMBER 13, 1993
12 - 2 PM

M E N U



SALAD

✓ Field Greens: Delicate Seasonal Greens with Honey Dijon Vinaigrette

Fresh Spinach Salad: with Julienne of Vegetables, Sliced Mushrooms and Diced Eggs. Warm Bacon Dressing.

ENTREE

✓ Court Grille: Petite Filet Mignon and Chicken Breast with Cabernet Wine Sauce and Candied Shallots

Maryland Crabcakes: Backfin Jumbo Lump Crabmeat with a New Orleans Remoulade.

Chef's Vegetables and Potato or Rice of the Day
Rolls and Butter

Double Chocolate Fudge Torte
Freshly Brewed Coffee, Tea and Decaffeinated Coffee

WHERE?

- 1. Monthly union meetings.
(Up to several hundred workers).**
- 2. Toolbox safety meetings.
(5-15 workers in crew).**
- 3. Focus groups.
(4-8 workers).**
- 4. Anywhere we can get them.
(?#s).**

GOALS:

- 1. Introduce workers to the basic concepts of ergonomics and to empower through language.**
- 2. Use a low-tech medium adaptable to the situations where there is access.**
- 3. Not to shut the lights off.**

Exposure to ergonomic risk factors may result in

CUMULATIVE TRAUMA DISORDERS

(CTDs)

Low Back Injury

Tendonitis/Tenosynovitis

Carpal Tunnel Syndrome

Bursitis

Strains and Sprains

ERGO / NOMICS

work

law

*"Fit the job to the worker,
not the worker to the job."*

Job Analysis

Exposure to the

RISK FACTORS

for work-related musculoskeletal disorders

TRAVELS *with you for life*

TEMPERATURE EXTREMES

REPETITIVE MOTIONS

AWKWARD POSTURES

VIBRATION

EXCESSIVE FORCE

LACK OF REST TIME

STRESS



TAB 2

University of Iowa Progress Report

1. PROGRESS REPORT- UNIVERSITY OF IOWA

Task I - Surveillance (RISS)

One mechanism for collecting data on work-related musculoskeletal disorders (WMD) in construction is to look at those workers who visit emergency rooms. While many WMD are the result of cumulative exposures, in many cases a single acute event may trigger an episode of pain or an injury. Since construction workers work on many sites and are constantly changing jobs, many often end up in emergency rooms. The University of Iowa, to capture this data, has developed a Rural Injury Surveillance System (RISS) to automate data collection from hospital emergency room and assure that certain data on occupation, industry and type of injury are collected. A manual for the system is in Appendix 1 of this Tab. We hope eventually to expand the system state-wide and be able to get state-based injury rates for these injuries. The RISS has made good progress and is on schedule to complete all its tasks for year 01.

A. Categorize SIC/SOC Codes. In consultation with consortium members and NIOSH, we decided to use SIC codes 15-17 (Building construction, other heavy construction and special trade contractors) to define construction workers for this surveillance project.

In conjunction with consortium members and NIOSH, we identified the following three digit SOC codes specific to this project:

631	Supervisors - construction
641	Brick masons, stone masons and hard tile setters
642	Carpenters
643	Electricians
644	Painters, Paperhangers, and Plasterers
645	Plumbers, Pipefitters, and Steamfitters
6468	Roofers
6473	Structural Metal Workers
646	Other
871	Construction Laborers

These categories were chosen on the basis of perceived variation in the risk factors for WMD in different trades and taking into consideration 1990 Iowa census data on the population in each trade. Small numbers may force us to analyze 6468 (roofers) and 6473 (structural metal workers) along with 646.

B. Define and Categorize Diagnostic Codes for WMD. Consortium members at GWU developed a list of three digit ICD codes that were likely to include most of the WMD (Appendix 2). In developing the list, they excluded categories which were thought to contain only a small number of WMD; they excluded conditions resulting from toxic exposures; they excluded categories containing primarily acute traumatic injuries; and they tried to consider the impact of misclassification and inaccurate diagnosis. This categorization will serve as a starting point which may need to be modified in response to the data. Specifically, our surveillance project should give us an estimate of the percentage of emergency room cases with each diagnosis that were felt to be work-related.

C. Construction Risk Factors. In order to keep the surveillance system simple and acceptable to the participating emergency rooms, we have added only a single risk factor to the RISS: union status. All patients in the construction SICs are being asked whether or not they belong to a union. This will enable us to compare patterns of WMD among union and non-union workers. Further risk factors could be evaluated in subsequent case-control studies.

D. Modification of RISS Software. Over the last year, we have modified the RISS software to include the data specific to this project (e.g. three digit SOC codes for construction, union status). In addition, we have extensively edited the software to make the system more user friendly. These changes have been well-received in the pilot hospitals.

E. The RISS Hospital Network. In conjunction with the Iowa Department of Public Health, we have recruited 12 hospitals to participate in this project (Table 1).

Table 1.

Hospital	City	ER Visits/year
Holy Family Hospital	Estherville	6,000
Palo Alto County Hospital	Emmetsburg	780
Loring Hospital	Sac City	3,000
Horn Memorial Hospital	Ida Grove	8,000
Stewart Memorial Community Hospital	Lake City	3,200
Pocahontas Community Hospital	Pocahontas	2,500
Spencer Municipal Hospital	Spencer	6,900
Buena Vista County Hospital	Storm Lake	6,000
Dickinson County Memorial Hospital	Spirit Lake	5,300
Osceola Community Hospital	Sibley	150
Marian Health Center	Sioux City	45,000
St. Luke's Regional Medical Center	Sioux City	<u>16,000</u>
		102,830

Covering a contiguous area in the northwest corner of Iowa, these hospitals represent the wide variety of facilities in the state.

F. Training and Supporting Hospitals. Discussions with the two urban Sioux City hospitals were held in July, 1993; we have a good first approximation of the tasks involved in setting up the system in these hospitals, but implementation has been put off until 1994 pending the availability of resources. Beginning in March, we met with the ten smaller hospitals to orient

them to the system. Throughout April, our ten hospitals piloted the software, discovering a variety of bugs and contingencies that we had not foreseen. Late in April, we held our first users group meeting to review the hospitals experience and concerns. All ten participating rural hospitals are now using the RISS software to enter data. Nine of the hospitals have been entering data since May, 1993, and one with software problems began entry in July, 1993. Data on a total of 15, 585 visits have been entered and transferred, involving over 12,000 people.

Since the hiring of a full-time programmer in June, 1993, necessary software changes needed to make the system easier to use and lead to more accurate data gathering have been made, based on the experience of the hospitals in the field. In addition, reports that can be generated at each hospital site for record-keeping, quality assurance, and state requirements have been modified at the suggestion of the hospitals. All members of the RISS staff are providing back-up and support in conjunction with the Iowa Department of Public Health.

G. Clean, edit and maintain database. In July, we received the first down-loaded data and developed editing and maintenance programs. We now receive data bimonthly, clean and edit as necessary, and add to our data base.

H. Analysis of Data. Preliminary analyses of data have focused on checking data for consistency and completeness. Checking data for completeness is now underway. We will complete the initial checks of data in December to see whether the RISS log compares with the handwritten emergency room log. Checking has been completed for four out of the ten hospitals. Two of these hospitals have RISS records that are as complete and accurate as the ER log. The other two hospitals have minor, readily correctable problems.

The amount of missing data for most of the basic demographic data is now negligible. N-codes, on which the determination of musculoskeletal disease is based are available for 82% of the visits on average since May, and the percentages have increased somewhat in later months. Two-digit SIC and SOC codes have already been entered by Emergency room staff into RISS; checks of the first nearly 50% of records occupation or industry coded as unknown or not coded for the entire six months. This decreased when the program was modified to separate homemakers, children, students, and retirees. The percent of records remaining with missing or unknown industry for September and October was 17.2% and for occupation was 22.5% on average, but there is still wide variation among hospitals. We have had several discussions with participating hospitals on how to improve coding. One major problem standing in the way of better coding is lack of information on the hospital chart. There are several apparent possible solutions to this problem which we have encouraged:

- 1) Enter the information while the patient is in the emergency room, rather than the following day, when most hospitals enter data. Two hospitals are now doing this to see how well it works in practice.
- 2) Gather the information necessary on a form for the patient's chart for entry. One hospital now does this, and it will be suggested to the rest of the hospitals at our next User's group meeting.

Other solutions will be explored over the next few months.

- I. Evaluation of the usefulness of the software system to participation hospitals.

Information about the user's satisfaction with the system has been gathered at several times. User's group meetings were held in July and September, 1993, with another planned for the second week of December. A telephone survey was completed in August, 1993 of the 10 participating hospitals to get their comments on the system and the reports generated. In addition, visits by the programmer and the project coordinator have been made to half of the hospitals verifying completeness of the data and talking with hospital administrators, ER directors, and medical records staff to see how useful the system is to them and elicit other comments. Early comments focused on software problems or desired improvements. Since the fall, discussion have focused more on the usefulness of the data to the participating hospitals and we have actively sought out administrators and records personnel to make sure they are getting the information they can use. In addition, we made major changes in the types of reports that the hospitals can generate based on these discussions. We feel these discussions have been very useful to the continued success of the system.

J. Validation of the SIC and SOC coding.

Validation will start in January, 1993. Trained coders will code occupation and industry from the free text field without looking at the data entry person's coding. If the accuracy is found to be a problem, or if completeness of coding cannot be improved in the hospitals with problems, one possibility is to code the 20 or 30 most common industries and occupations for each hospital and add them to the software in a pull-down list to refer to, or at a minimum give a card with these industries, occupation, and codes to each hospital for their reference. The acceptability of this will be explored at a user's meeting in early December, 1993.

K. Evaluation of the effectiveness of RISS in capturing WMD.

This evaluation will be performed over the next six months as more data are captured by the RISS system.

Task II - HAZARD IDENTIFICATION.

To meet its objective of collecting, organizing, and disseminating existing information on WMD hazards and ergonomic interventions in the construction industry, The National Hazard Communication Resource Center's (NHCRC) work during the first year of the WMD project has been organized around the following five tasks:

- 1) Compile information resources on WMD and ergonomics in construction
- 2) Publish annotated bibliography on WMD and ergonomics
- 3) Define key concepts for database linkage
- 4) Enter information in hypertext database
- 5) Elaborate and implement dissemination strategy

A. Compile Information Resources on WMD

Compiling information resources on WMD and ergonomics in the construction industry involved a two part process. The major focus was collecting and organizing the available research literature on WMD and ergonomics (including information on any available ergonomic

interventions/control technologies) in the construction industry. The citations with abstracts from this collected research literature have been entered into the WMD database. This research level of the database is now available for telephone requests for information and will be updated as research becomes available from the literature and consortium.

The technical research literature was classified as much as possible under the appropriate trade categories or, when necessary, under the general heading of construction industry. The major ergonomic exposure-response associations available from the research literature have also been extracted from this literature in preparation for dissemination during the second year.

The second step of this process, which has been a specific emphasis since July, entailed searching, locating, and collecting other professional literature, trade publications, and lay summaries from available literature. This literature was also analyzed for any solutions presented for controlling ergonomic hazards in the construction industry. While much of this literature is of questionable value, it is useful for understanding how WMD and ergonomic terms and concepts are being transferred to different audiences in the literature. Approximately two hundred of these articles have been collected to date, although many are not construction specific.

B. Publish Annotated Bibliography on WMD and Ergonomics

The annotated bibliography on WMD and ergonomics in the construction industry, Work-Related Musculoskeletal Disorders: A Construction Bibliography, was published by CPWR for the National Convention in July. A copy is included in Appendix 3 to this Tab. Between three to four hundred copies of the bibliography have been distributed to date. The bibliography was also distributed at the annual Governor's Health and Safety Conference held in Des Moines Iowa, November 16-18. This bibliography is stored in a computerized database and will be updated and kept continuously available (through CPWR publications) to those in the construction industry and other interested researchers and professionals.

To keep the WMD database current, the National Library of Medicine's Medline database, the Excerpta Medica database, and the National Institute for Occupational Health & Safety's NIOSHTIC database are searched at the beginning of each month. This insures world-wide coverage of the major research journals relevant to our search topic. No major WMD or ergonomic articles specific to the construction industry were located during August-September, although a few articles on other topics mentioned the problem of musculoskeletal disorders in the industry. Thirty four article citations with abstracts related to WMD and ergonomics (in general) were added to the WMD database, including the article "Revised NIOSH equation for the design and evaluation of manual lifting tasks," which recently appeared in the journal Ergonomics. Although including these citations must be a selective process, the intent is to keep the WMD database current with the latest and most relevant published research that could be of use to those in the construction industry. Until there is more construction specific research available WMD and ergonomics, including these citations in the database will keep those in the construction industry informed of the latest research, both theoretical and in other industries.

In addition, the University of Iowa's OASIS online book catalog and the commercially available (through the OASIS service) Wilson periodical databases are searched each month. The Wilson databases provide a good resource for searching trade (e.g., ENR) and professional publications. Only the exceptional article from these sources is entered into the research

database, sufficient quality are not in the process of being entered into a companion bibliographic WMD/Ergonomic database specific to this type of literature. This will allow them to be easily accessed if useful for the second year dissemination plan.

C. Define Key Concepts for Database Linkage and Dissemination

As part of the process of collecting and organizing the technical research and other literature available, this literature was analyzed for the important concepts and terms that must be included in the consortium's information dissemination strategy. This initial strategy can be summarized under the general categories of the ergonomic risk factors/tasks, signs and symptoms, and WMD outcomes.

D. Enter Information in Hypertext Database

At the third Project Working Group Meeting held in Iowa City in June two fundamental questions were addressed that are essential to the effectiveness of this step of the NHCRC's WMD information dissemination strategy. Since the overall project is focused on primary prevention, it was decided that such a strategy should target construction industry employers and workers, as they are the key to reducing and preventing WMD injuries in the industry. An effective strategy to achieve this objective must address two fundamental questions:

- 1) How do we get information in the hands of construction industry employers and workers?
- 2) How best should the information be developed and presented for maximum use by these targeted groups?

The third WMD Project Working Group concluded that to enter WMD and ergonomic information designed for the hypertext (or summary outreach) level of the database before we could satisfactorily answer these essential questions would be an inefficient use of resources. The strength of a knowledge or information management system that combines different software programs into an organized whole is that it can be developed in response to the growing understanding of the consortium's information management and dissemination needs. Thus, the working group agreed that the existing written communication structure for information exchange in the construction industry would be used to acquire practical knowledge for answering the above questions. As the group learns more about which concepts and terms are most useful in communicating to both worker and contractor, the hypertext level of the database will be developed in response to this knowledge during the second year.

E. Elaborate and Implement Dissemination Strategy

The results of the discussion at the third working meeting have been formulated into an action plan for an WMD dissemination strategy by Pete Stafford of CPWR (See Appendix 8 of CPWR report) . This action plan will be carried out in the Year 02.

To prepare for implementing the action plan, the focus during the final quarter was on determining which concepts and terms should be consistently included during the initial dissemination to the various trades. This initial strategy will focus on raising the awareness of

the ergonomic/WMD problem by illustrating the known of suspected ergonomic exposure response relationships in each particular trade through the research that is available on the trade. To accomplish this, the construction literature was analyzed by trade for ergonomic risk factors/tasks, sign and symptoms, and WMD outcomes. Possible preventative measures and other solutions have also been noted as available. A synopsis of the ergonomic exposure-response associations from the literature can be found in the appendix (Appendix 4 of this Tab).

Summary articles that emphasize the ergonomic exposure-response relationship will be published in the various trade publications by the International Brotherhood of Electrical Workers is included in the appendix.

Task III - Ergonomics Training.

Because of delays in hiring a qualified research assistant, several first year objectives have been slightly delayed. Additionally, changes in the administrative structure of one of the labor-management groups have contributed to some delays. As a result planned site visits could not be made during the first grant year. However, progress towards achieving first year objectives includes the following:

A. The symptom and job factors survey (Appendix 5 of this Tab) has been under revision and modification and should be administered during the first quarter of the year 02. Analysis and presentation of results will take place during the second quarter of year 02.

B. Three pilot focus group meetings have been held with mixed-trade groups to help define the format of future meetings. During these meetings, initial reactions to various video training materials were obtained. The three pilot focus group meeting were held at Kirkland Community College in Cedar Rapids, IA as part of a Safety and Health in Construction education series sponsored by the Eastern Iowa Construction Alliance. The dates were January 19th, February 2nd and February 9th, 1993. Each two-hour session consisted of approximately one-hour general presentation on Ergonomics for the entire group, followed by an approximately one-hour discussion by 10-12 participants. A total of 93 construction workers from 12 trade groups attended the three sessions while 30-35 participated in the more in-depth discussions. An outline of the presentations is attached as Appendix 6. The discussion sessions were less structured and centered around topics such as workers' perceptions about major musculoskeletal ergonomic hazards and about the major impediments to eliminating those hazards. The principle outcome of those sessions was a consensus that the proposed format used in these sessions could be effective in exchanging information about ergonomics in the construction trades. All participants in the discussions expressed an eagerness to have project personnel meet with their individual trade groups.

C. Resources were garnered to renovate and make operational a new Biomechanics/Ergonomics Facility which will provide state-of-the-art biomechanical analysis capabilities for defining and understanding ergonomic hazards and proposed interventions for reducing WMD.

D. A training needs survey was conducted within one labor management council (the Eastern Iowa Construction Alliance) and data are being collected from the other councils. The

survey identified musculoskeletal injuries as the second most important area in need of additional training.

E. As proposed, personnel have participated in work group meetings to identify hazards and to begin developing training programs.

F. Project personnel attended four project planning meetings and had numerous interactions with personnel from the other cooperating institutions. Project personnel also participated in the international conference in Washington and made presentations at several conferences and seminars including the Iowa Governor's Safety conference, the American Physical Therapy Association annual conference, the Occupational Health Nurses conference.

Task IV - Longitudinal Study.

Preliminary discussions have been held concerning the ways in which a longitudinal study could be designed, but the major issues can not be confronted until data from the current project is available for analysis.

TAB 2

APPENDIX 1

Rural Injury Surveillance System (R.I.S.S.) Manual

R.I.S.S.

Rural Injury Surveillance System

The University of Iowa

Injury Prevention Research Center

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INTRODUCTION

The objective of the Rural Injury Surveillance System (RISS) is to collect data on all patients as they visit the Emergency Department. The system has been developed to capture information about the patient's visits that is presently written down in often illegible Emergency Department logbooks. In order to obtain valid and reliable data, the system has been made as attractive and user friendly as possible. Included are easy to generate reports to assist in quality assurance, state mandated reports that use information already available in the system, utilities that customize the system to the individual user, and many help-windows ensuring no invalid input.

For questions about the system, please call or write to:

Mario Schootman
University of Iowa
Injury Prevention Research Center
Oakdale Campus
Iowa City, IA 52242
Ph #: (319) 335-4233 (office)
or : (319) 354-5470 (home)

COMPUTER SYSTEM REQUIREMENTS

To run the RISS-system requires an IBM PC compatible computer with a CPU of at least 286 with a harddrive. A CPU of 386 is preferable as is a color monitor and mouse. The RISS-system requires further 640 RAM to run. The size of all RISS-programs equals about 3 Megabytes. This can rapidly increase as the number of records increase. The config.sys file needs to be modified to contain "files=50" since at some points during the execution of the RISS-system several files may be open simultaneously.

OPERATING INSTRUCTIONS

1. The RISS-system can be used with or without the use of a mouse.
2. In this manual <a> is used to denote that the key a has to be pressed to perform a specific function.
3. An option from any menu can be selected by either:
 1. using the cursor-keys to the desired option and pressing <Enter>
 2. typing the highlighted letter of an option, i.e. using "hot keys"
 3. typing a designated letter or number to select a particular predetermined category of a certain field
4. To move from field to field on a screen the following keys can be used:
 1. cursor keys (down arrow, up arrow)
 2. <Tab>, to move to the next field, or <Shift><Tab> to move to the previous field.
5. To go to the next screen, use <PageDown>. To go to the previous screen press <PageUp>.
6. Pressing <Esc> will abort the current popup window or screen.
7. Help for a particular field is displayed on the screen by pressing <F1> at any time. {If the system asks for the name of a data base, select hlp-riss.dbf}
8. There are three types of fields; free text fields, fields that have predetermined categories, and date and time fields. Free text fields are those fields in which text (sentences, etc.) can be entered. A predetermined category can be selected by either using the popup window or by typing in the appropriate number or letter that accompanies each category. See the Facility-option of the Utilities-menu for determining when the windows with predetermined categories should be displayed on the screen.

On each screen there will be some space underneath the box that displays the fields in which data needs to be entered. In this space the selection that was made for fields that have predetermined categories will be displayed. For example, if Female is selected for the patient's sex, the box will display Female until a selection for the next field is made.

The data entry process can be aborted at any time by pressing <Ctrl> and <w>. The program then asks to accept (by pressing <a>) or ignore (by pressing <i>) the data that was entered before aborting the program. If the user decides to accept the data, it will be saved in the existing database. If <i> is pressed, the entered data of this record before aborting the program will be lost. In both cases the program will then go back to the main menu (Entry, Reports, and Utilities).

I. DATA ENTRY AND MODIFICATION

After starting the RISS-system, the first screen that will be displayed on the computer monitor is the following:

Entry	Reports	Utilities
1. Add New ER Record		
2. Modify Existing ER Record		
3. Provider Information		
4. Release Instructions		
5. EMS Company Information		
6. Quit		

This screen shows that the RISS-system consists of three main menus:

1. Entry, which allows new data to be entered and modification of existing data.
2. Reports, which allows the user to generate reports using existing data.
3. Utilities, which has the capability of exporting data and setting defaults (initial settings) for the RISS-system.

Each of the items of each of the three menus will now be discussed in further detail.

A. Add new ER Record

After selection of this item of the Entry-menu, the question "Is this the patient's first visit" is asked. This is to determine if the RISS-system needs to retrieve demographic information of an existing patient in order to reduce data entry by the users. If the above question is answered N, demographic information will be retrieved by the system. If the answer is Y (Yes), the following screen will be displayed.

Patient Name (L) _____	(F) _____
Social Security Number: ___ - ___ - ___0	
Hospital ID # _____	

Three options are available.

1. View all patients in the database.

Press <Enter> four times or <PageDown> once which will display the name, social security number, and hospital ID number of all patients currently in the database. After selecting a particular patient, the computer will retrieve all available information and display it on the screen. Not entering information may be helpful

when it is unknown if information on a patient has already been entered into the system and thus avoid duplication or if the user is unsure how to spell the patient's name, Social Security Number or hospital ID number. Selecting an existing patient will be interpreted by the computer that the same patient came back to the Emergency Department for the same or a different health problem.

2. View only certain patients.

After entering information in one or more of the fields, the computer will search through its records and will display on the screen those records at least matching the information entered in one (or more) of the four fields.

For example, suppose data is available on five patients:

Patient Name (L)	(F)	Soc. Sec. #	Hospital ID #
SMITH	JOHN	111-22-3333	11111
SMITH	ERIC	111-32-8989	11112
SMITHE	MARY	322-55-8989	11113
SCHOOTMAN	MARIO	878-99-7678	11114
SMIT	JOHN	555-34-1245	11115

If the user decides to type in "SMITH" for the Patient Name (L) and presses three times <Return> or <PageDown>, the computer will display the first three names on the screen. If, however, only "S" was typed in for the Patient Name (L), the computer will display all five records since all last names start with "S". By using either method, the user can then choose among those records one that needs to be modified, updated, or just displayed on the screen. The computer will retrieve all currently available information of a patient and display this on the screen.

Combinations with two or more fields can be made also. For example, if the user types in "SMIT" for the Patient Name (L) and only "J" for the First name, the computer will display the first, third and last record since the names start at least with the letter sequence "SMIT" and the first names start at least with "J". Combinations with all four fields can also be made. Selecting an existing patient will be interpreted by the computer that the same patient came back to the Emergency Department for the same or a different health problem. See the Facility-option of the Utilities-menu for determining when the windows with predetermined categories should be displayed on the screen.

3. New patient.

Enter the full name, social security number, and hospital ID number of a new patient as he or she comes to the Emergency Department.

After either selecting data of an existing patient (a patient who came to the Emergency Department before) or entering information of a new patient, the Patient Demographics screen will be displayed.

RISS - Rural Injury Surveillance System Facility ID 1111
 01/30/92

Social Security Number ___ - ___ 0 Hospital ID _____

Name (L) _____	Name (F) _____	(M) _
Date of Birth: 01/30/92	Sex: _	Marital Status: _
Race: _	Phone #: (____)____ - ____	
Address: _____	Within City Limits: _	
Street: _____	County: _____	
City: _____	Country: _____	
State: __	Zip: _____	- _____

Press {Ctrl-W} to Exit

If an existing patient was selected, all or most of the fields will be filled out. If, on the other hand, a new patient was entered into the system, only the patient's name, Social Security Number, and Hospital ID # will be filled out. All other fields will be blank except the country the patient currently lives in.

Description of the fields.

Social security number: The patient's social security number.

Facility ID: Each hospital will be assigned a unique identification number by members of the RISS data management team in order to discriminate between hospitals.

Hospital ID: The patient's hospital identification number. This number is entered into the system by the user and is a unique number for each patient.

Name: Last (L), First (F), and middle initial (MI) of the patient.

Date of birth: When was the patient born.

Sex: The gender of the patient, which will be either Male, Female, or Unknown.

Marital Status: The marital status of each patient is classified as being Married, Never married, Divorced, Widowed, Separated, or Unknown.

Race: The race of the patient is categorized into: White, non-Hispanic; Black, non-Hispanic; American Indian/Eskimo/Aleut; Asian or Pacific islander; Other race; or Unknown.

Phone #: The patient's home phone number.

Address (as of): Because patients can move between visits we ask for their current address and when they started living there.

Within City Limits: Does the patient live within city limits? This is classified as either Yes, No, or Unknown

Street, City, County, State, Zip-code, Country: Where did the patient live at the time he/she came into the emergency room.

After pressing <Enter>, <PageDown>, or the down arrow key on the last field (Zip-code of the patient), the program will display the next screen which consists of information regarding employment and contact person.

01/30/92

EMPLOYMENT INFORMATION		
Type of Industry: _____	SIC code: ____	
Type of Occupation: _____	SOC code: ____	
Employer Name: _____		
Employer Address: _____		
City: _____	State: __	Zip: ____-____

CONTACT PERSON		
Name (L): _____	Name (F): _____	(M) _
Relationship: _____	Phone: (____) ____-____	
Address: _____		
City: _____	State: __	Zip: ____-____

{Ctrl-W} to Exit

01/30/92

Patient: _____	Hospital ID: _____
----------------	--------------------

Date In: 01/30/92 Time In: __:__ ER log #: _____
Reason for Visit: _____

Injury: _	Date of Onset: 01/30/92	Time of Onset: __:__
Address of Injury: _____		
BP, Resp, Neuro Normal? _	Sys BP: _____	Resp Rate: __ ATS: __
Motor Response: _	Verbal Response: _	Eye Opening: _ GCS: __
E-codes: _____	Place of Occurrence: _	
Within City Limits: _	Intentional: _____	
Work Related: _	Brain/Spinal Cord Injury: _	
Farm Related: _	Substance Abuse: _____	

{Ctrl-W} to Exit

Description of the fields.

The name (Last, First, and Middle Initial) and Hospital ID # are copied from the first to the Visit-screen. Data on other fields have to be entered by the user.

In (date and time): These fields refer to the date and time that the patient came to the Emergency Department. Although the computer automatically puts the current date on the Date-in field, this can be changed by typing over it. Time is recorded in military time (24 hours).

ER Log #: This is a sequential number which identifies each visit of the patient. Therefore, patients that came in more than once will have more than one ER Log Number.

Reason for visit: What was the reason that the patient came to the Emergency Department? List in this free text area the chief complaint of the patient.

Date of onset: Date of onset of the injury or illness.

Time of onset: Time of onset of the injury or illness. Report this in military time (24 hour clock).

Injury: Did the patient come to the ER because of an injury (enter Y for Yes) or illness (enter N for No).

Definition of injury: An acute alteration of body structures caused by energy transfer (chemical, mechanical, thermal,

electrical or ionizing radiation) which exceeded the mechanical properties of the aforementioned structures resulting in an ER visit.

Only certain fields require data entry depending on whether the reason for visit was an injury or illness. If the reason for visit was an ILLNESS, the computer will jump to the field Substance Abuse. This means that information on the Address of injury, the Adult Trauma Score, External Causes of Injury (E-codes), etc. do not have to be filled out. If, on the other hand, the Reason for Visit was an INJURY, the rest of the fields that are displayed on the Visit-screen require information.

Address of injury: The exact location where the injury occurred. Be as specific as possible.

BP, Resp, Neuro Normal? This field determines the severity of trauma present and can be used to triage the incoming adult patient. Two possibilities exist:

1. If Systolic Blood Pressure, Respiratory Rate and Neurologic exam are normal, enter Y for Yes:

The computer assumes that the patient has a mild injury and assigns the highest values to the Glasgow Coma Scale and Adult Trauma Score, which are 12 and 15 respectively. The individual components of the Adults Trauma Score (the Systolic Blood Pressure, Respiratory Rate, Best Motor Response, Best Verbal Response, and Eye Opening) do not have to be filled out by the user. The computer skips to the External Causes of Injury (E-codes).

2. If Systolic Blood Pressure, Respiratory Rate and/or Neurologic exam are not normal, enter N for No:

The computer will bring up the predetermined categories for the Systolic Blood Pressure, Respiratory Rate, Best Motor Response, Best Verbal Response, and Eye Opening Response. The user has to enter data in these fields. Another possibility is to enter the actual values for Systolic Blood Pressure and Respiratory Rate and use the predetermined categories for the other fields. The computer will automatically assign the appropriate codes for the Adult Trauma Score to the Systolic Blood Pressure and Respiratory Rate based on the entered values.

The following predetermined categories have been created to arrive at a score for the Adult Trauma Score:

Systolic Blood Pressure:

Greater than 89 mm Hg, 76-89 mm Hg, 50-75 mm Hg, 1-49 mm Hg, 0 mm Hg.

Respiratory Rate

10-29, More than 29, 6-9, 1-5, 0 times per minute.

Best Motor Response

Purposeful movement on command, Localization of pain, Withdrawal from pain, Extremity flexion with painful stimulus, Extremity extension with painful stimulus, No response.

Best Verbal Response

Well-oriented conversation, Words or phrases, Incomprehensible vocal sounds, Grunts, No response.

Eye Opening Response

Spontaneous, To voice, To pain, No response.

E-codes: The cause of the injury is based on the External codes (E-codes) of the International Classification of Diseases Clinical Modification Ninth Revision (ICD9). The entire data set of ICD9 E-codes will be used. There are four levels the user has to go through in order to arrive at the final E-code. At each level the user will pick a certain choice that best describes the circumstances under which the injury occurred. The various levels are build in a hierarchical way. This means that by choosing a certain category, the computer will display subcategories for this category. After picking a subcategory, the computer goes to the third level and displays choices that describe both categories chosen by the user. Picking a category from the third level will bring up the final choices. Select the one category that best describes the circumstances under which the injury occurred. The code that accompanies this description will be displayed in one of the boxes marked "E-codes" on the Visit-screen. Up to four E-codes can be entered in the RISS-system depending on the number of different mechanisms by which the injury occurred. The user can also enter the E-code directly into the appropriate box, if he or she knows which E-code describes the injury sustained by the patient. Appendix 2 lists all E-codes that are available with specific examples.

For example, a person hit by a car while crossing the street arrived at the Emergency Department one day is coded in the following way. When <F2> is pressed while being in an E-code field, the window will be displayed on the screen with the first level of E-codes. Select "Transport Related Accidents". This will trigger the second level of which "Motor Vehicle Traffic Accidents" best describes the hypothetical example. From the third level of E-codes, "Motor Vehicle Traffic Accidents involving collision with pedestrian" needs to be selected. This will result in the display of the final window from which "814.7 Injury pedestrian" is the correct choice.

Place of occurrence: Place of occurrence where the injury occurred. Based on the ICD9 codes the following categories will be used: Home, Farm, Mine & quarry, Industrial place & premises, Place for recreation & sport, Street & highway, Public building, Residential institution, Unspecified place.

Within City Limits: Did the injury occur within city limits (enter Y for Yes). If the injury occurred outside city limits enter N for No. If it is unknown whether the injury occurred inside or outside city limits, enter U for Unknown.

Intentional: This classification is based on evidence or possibility that the injury was deliberately self-inflicted or inflicted by another. The following categories have been coded: Intentional, Suspected, Unsuspected.

Work-related Injury: The injury is considered work-related when the following criteria have been met.

The injury occurred in the course of employment. Transportation to and from work is not included. Transportation related events should be included if transportation was part of the job. Homemakers, housewives for example, in their own residence are not considered work-related. Includes assault at work, injury in a family business or farm.

If the abovementioned definition is met, the injury is work related (enter Y for Yes). If the injury is not work-related based on the criteria, enter N for No. It may also be unknown (U) whether or not the injury is work-related.

Brain/Spinal Cord injury: A brain and/or spinal cord injury has been sustained when the following conditions have been met (from the Iowa Central Registry for brain and spinal cord injuries).

Brain injury: Any clinically evident damage to the brain which results directly or indirectly from acute exposure to physical or chemical agents, anoxia, or infection of vascular regions which are not primarily related to degenerative or aging processes and which temporarily or permanently impairs a person's physical or cognitive function.

Spinal cord injury: Any clinically evident damage to the spinal cord, including hemiplegia and paraplegia, which results directly or indirectly from acute exposure to physical or chemical agents, anoxia, infection of vascular regions including aortic injury, which are not primarily related to degenerative or aging processes and which temporarily or permanently impairs a person's physical functions including sensory and motor functions and bowel and bladder functions.

If the patient has a brain injury, a spinal cord injury, or both by using the criteria listed above, enter Y for Yes. If the patient has neither a brain or spinal cord injury, enter N for No. If it is unknown if the patient has a brain or spinal cord injury, enter U for Unknown.

If a patient sustained a brain and/or spinal cord injury, the Iowa Department of Public Health requires that a special form needs to be filled out. The appropriate screens will be displayed after all information is entered into the RISS-system. See page . for a description of the form.

Farm-related injury: A farm-related injury has been sustained when the following criteria have been met (from Iowa Farm Injury Report).

A non-household injury incurred on the farm by any farmer, farm worker, farm family member or other individual, or any off the farm injury incurred by a farmer, farm worker, or farm family member in the course of handling, producing,

processing, transportation, or warehousing farm commodities. Reportable injuries would include those incurred by non-farmers who are on the farm for a wide variety of purposes: visiting, hunting, swimming, and other recreational activities.

Enter Y for Yes if the above criteria apply, enter N for No if the above criteria have not been met, enter U for Unknown.

If a patient sustained a brain and/or spinal cord injury, the Iowa Department of Public Health requires that a special form needs to be filled out. The appropriate screens will be displayed after all information is entered into the RISS-system. See page . for a description of the form.

Substance abuse: When the Mini-DAWN is required to be filled out for the Iowa Board of Pharmacy Examiners, enter Y for Yes. If it is not, enter N for No, enter U for Unknown.

After pressing <Enter> or the down arrow key on the last field of the second screen (Substance Abuse) or after pressing PageDown, the program will display the Arrival-screen.

01/30/92

Patient: _____	Hospital ID: _____
Social Security Number: ___-___-___	Visit Date: 01/30/92

ARRIVAL	
EMS Code: 0	
EMS ID Number: __0	
EMS Run Number: __	
EMS Company: _____	

Press (Ctrl-W) Exit

The name (Last, First, and Middle Initial), Hospital ID #, Social Security Number, and Visit Date are copied from the first to this screen. Data for other fields have to be entered by the user.

Description of the fields

ARRIVAL INFORMATION

EMS code: The mode of transportation by which the patient arrived at the Emergency Department by using the following predetermined categories: Ground ambulance, Rotor air ambulance, Fixed wing ambulance, Public safety vehicle (non ambulance), Private vehicle, Walk-in, Other, Unknown.

If the patient came by ambulance (EMS code = 1,2 or 3), the

computer will ask for information on the EMS Identification number, Run number, and Company name.

EMS ID Number: The identification number of the EMS vehicle that brought the patient to the hospital.

EMS Run Number: The Run Number of the EMS vehicle that brought the patient to the hospital.

EMS Company: The name of the company to which the vehicle belongs that brought the patient to the hospital. By pressing <F2>, a list of available EMS companies will be displayed.

After pressing <Enter> or the down arrow key on the last field of this screen (EMS Company) or after pressing <PageDown>, the Disposition-screen will be displayed.

01/30/92

Patient: _____	Hospital ID: _____
Social Security Number: ___-___-_____	Visit Date: 01/30/92

Diagnoses: (N-codes)	
Code	Description
1: _____	_____
2: _____	_____
3: _____	_____
4: _____	_____
Disposition: 0	

Press (Ctrl-W) Exit | F2 - Code Lookup

The name (Last, First, and Middle Initial), Hospital ID #, Social Security Number, and Visit Date are copied from the first to this screen. Data on other fields have to be entered by the user.

Description of the fields

DISPOSITION

Diagnoses: Enter here the diagnoses of the patient. More than one diagnosis can be entered. The first diagnosis is the illness or injury chiefly responsible for the patient's visit to the Emergency Department. The first three digits of the ICD9 N-codes will be utilized.

The ICD9 N-codes are build in a hierarchical way. This means that by choosing a certain category, the computer will display subcategories for this category. After picking a subcategory, the computer goes to the third level and displays choices that describe both categories chosen by the user. Picking a category from the third level will bring up the final choices. Select the one category that best describes the diagnosis of the injury or illness. The code that accompanies this description will be displayed in one of the boxes marked "Code". Up to four N-codes can be entered in the RISS-system depending on the number of injuries or illnesses of the patient. The user can also enter the N-code directly into the appropriate box, if he or she knows which N-code describes the injury or illness of the patient.

Disposition: Enter here the disposition of the patient as he or she leaves the ER. The following categories are used: Return to ER (As needed), Return to ER appointment, Return to referring physician, Return to other physician clinic, Admit to hospital ICU, Admit to hospital OR, Admit to hospital other, Transfer to other facility, DOA/died in ER, Left against medical advise, Treated and released, Other.

If the patient is transferred to another facility (Disposition is 8), the COBRA-form needs to be filled out at the transferring ER before sending the patient to the other facility. The appropriate screens will be displayed after all information is entered into the RISS-system. See page . for a description of the form.

After pressing <Enter> or the down arrow key on the last field of this screen (Disposition) or after pressing <PageDown>, the program will display the Provider-screen.

01/30/92

Patient: _____	Hospital ID: _____
Social Security Number: ___-___-_____	Visit Date: 01/30/92

Provider Code: _0
Provider Number: _0
Provider Name: _____
Consultants: _0 _0 _0 _0 _0
Instruction Code: _0
Print Release Instructions: __

Press (Ctrl-W) Exit

The name (Last, First, and Middle Initial), Hospital ID #, Social Security Number, and Visit Date are copied from the first to this screen. Data on other fields have to be entered by the user.

Description of the fields

PRIMARY PROVIDER

Hospital provider code: The type of provider responsible for the care of the patient at the ER. The following predetermined categories have been created: Physician, Nurse, Nurse Practitioner, and Physician's assistant.

Provider number: In order to be able to distinguish between different providers, each provider has been given a unique number.

Provider name: Name of the provider.

Consultants: The number of the consultant who also contributed to the diagnosis and/or treatment of the patient.

Instruction Code: If the patient has been treated and released, the physician may give the patient a set of standard instructions by using a specific numeric description code. Release instructions can be entered into the RISS-system by selecting "Release Instructions" from the Entry-menu.

Print Release Instructions: Release Instructions can be printed out by typing Y. The default is N.

B. Modify existing ER record

After selecting this option from the Entry-menu, the message "Is this the patient's first visit" will be displayed. If it is, type Y. If this is not the patient's first visit, type N.

If it is not the patient's first visit, the following screen will be displayed which is the same as when adding a new ER record.

Patient Name (L) _____	(F) _____
Social Security Number: ___ - ___ - ___ 0	
Hospital ID # _____	

Two options are available.

1. Review all patients in the database.

After pressing <Enter> four times or <PageDown> once, the next screen will be displayed which consists of the Name (Last and First), Social Security Number, and Hospital ID Number of all patients currently in the database.

2. View only certain patients.

By entering information in one or more of the four fields, the computer will search through its records and will display on the screen the records matching the entered information entered. See also Adding a new ER record on page . .

After selecting a certain patient, the Patient-visit-screen will be displayed which lists all visits of the selected patient.

RISS - Rural Injury Surveillance System

Social Security Number ___ - ___ - ___ Hospital ID _____

Name (L) _____	Name (F) _____	(M) ____
----------------	----------------	----------

Patient Visits			
01/28/92	1	Y	11
01/28/92	2	Y	12
01/27/92	3	N	13

The column to the left is the date of the patient's visit to the Emergency Department, which is followed by the visit number, and either "Y", indicating an injury or "N" indicating an illness. The reason for visit of the selected patient is displayed next. The column most to the right is the ER Log Number.

By selecting a certain visit of a certain patient, the Modification-screen is displayed.

RISS - Rural Injury Surveillance System

Social Security Number ___-__-____ Hospital ID _____

Name (L) _____	Name (F) _____	(M) _____
----------------	----------------	-----------

S.S.N ___-__-____

Hospital ID _____

Visit Date 01/30/92

Er Log # _____

ESC-Quit	
< Demographics >	
<Employ-Contact >	
< Visit >	
< Arrival >	
< Disposition >	
< Provider >	
< Farm >	
< Brain Spinal >	
<Substance Abuse>	
< Cobra >	

The box to the right lists the various screens that has information on the patient that can be modified. Screens that are not available, which have a different color, cannot be selected.

By selecting the appropriate field in this window, the computer will display the information of the selected patient and visit after which the user can make modifications. For example, when "Visit" is selected the computer will display the screen as is shown on page .

C. Provider information

After selection of the Provider information from the Entry-menu, the user will be able to add, modify, and delete names and the accompanying number of the hospital provider. These providers can be linked to release instructions which can then be given to patients after they are treated and released.

University of Iowa Hospitals and Clinics

```
< Add >  
< Mod >  
< Del >  
< Last >  
< Prev >  
< Next >  
<First >  
<Browse>  
< Quit >
```

Provider Number: ___

Provider Name: _____

The box on the left displays the available selections:

Add: Add a new Provider Number and Name

Mod: Modify an existing Provider Number and Name

Del: Delete an existing Provider Number and Name

Last: Go to the last Provider Number and Name

Prev: Go to the previous Provider Number and Name

Next: Go to the next Provider Number and Name

First: Go to the first Provider Number and Name

Browse: Browse through all existing Provider Numbers and Names
(Pressing <Esc> brings back the menu)

Quit: Return to the main menu

D. Release instructions

By selecting the Release Instructions, the user will be able to add, modify, and browse through specific instructions to be given to certain patients. The following screen will be displayed:

University of Iowa Hospitals and Clinics

<p>< Add > < Mod > < Del > < Last > < Prev > < Next > <First > <Browse> < Quit ></p>	<p>Instruction Number: _____</p> <p>Instructions: _____ _____ _____ _____</p> <p>Provider Number: _____</p>
--	--

The box on the left displays the available selections:

Add: Add a new Instruction

Mod: Modify an existing Instruction

Del: Delete an existing Instruction

Last: Go to the last Instruction

Prev: Go to the previous Instruction

Next: Go to the next Instruction

First: Go to the first Instruction

Browse: Browse through all existing Instructions (Pressing <Esc> brings back the menu)

Quit: Return to the main menu

The Instruction Number in the right box is used to identify each instruction by a unique number for each provider. This means that, for example, both provider 1 and provider 2 can have different instructions but both numbered 1 through 10.

In the "Instructions" section of the same box, the user can type in the description of the instructions to be given to a particular patient. After the cursor arrives at the field marked "Provider Number" a message is displayed at the bottom of the screen, "F2 - Lookup Provider Number", which enables to lookup all available providers by number.

E. EMS company information

By selecting the EMS Company Information, the user will be able to add, modify, and browse through specific EMS Company Names. The following screen will be displayed:

University of Iowa Hospitals and Clinics

< Add > < Mod > < Del > < Last > < Prev > < Next > <First > <Browse> < Quit >	EMS Company Number ____ EMS Company Name _____
---	---

The box on the left displays the available selections:

Add: Add a new EMS Company Name

Mod: Modify an existing EMS Company Name

Del: Delete an existing EMS Company Name

Last: Go to the last EMS Company Name

Prev: Go to the previous EMS Company Name

Next: Go to the next EMS Company Name

First: Go to the first EMS Company Name

Browse: Browse through all existing EMS Company Names (Pressing <Esc> brings back the menu)

Quit: Return to the main menu

The box on the right is used to add, delete, modify, and lookup EMS Company Names. Each Company is identified by a unique identification number known as the EMS Company Number. The name of the EMS Company can be typed in the field below the EMS Company Number.

F. QUIT

By selecting Quit from the main menu, the RISS-system will be aborted.

II. REPORTS

Entry

Reports

Utilities

1. Daily Log
2. Diagnoses Report
3. Injury Report
4. Demographics Report
5. Ad Hoc Report

Reports 1 through 4 have been created to display the report capabilities of the RISS-system. In future versions of the system, additional reports will likely be created to suit the individual hospital's needs and requirements

1. Daily Log

By selecting this option, the daily ER log can be displayed for a specific day or period. The output can be displayed on the screen or send to the printer.

2. Diagnoses Report

3. Injury Report

4. Demographics Report

5. Ad hoc Report

By selecting this option, the user can generate his or her own reports by using ANALYSIS from a computer program called EpiInfo made available at no cost by the Centers for Disease Control. Selecting this option of the Reports-menu will immediately link into this program. A brief discussion of a some command will follow. The necessary commands are written in upper case letters, while lower case letters denote a discussion of the commands. See the EpiInfo manual for additional information about the system.

a. Select file

READ filename1 filename2

Filename1 and filename2 are the names of existing foxpro database files. See appendix . for a listing of all foxpro datafiles. To use the Ad hoc report capabilities, the extension of the files must be .dbf. Type in for example READ VISITINF.DBF

b. Select ranges of variables

SELECT expression

For example to select only patients with an injury, type in SELECT INJURY="Y". Press <F4> to see that in the column injury only y's are displayed. Ranges for more than one variable can also be made by using AND, for example SELECT INJURY="Y" AND GCS<15. After pressing <F4> it can be seen that only those injured patients with a Glasgow Coma Scale lower (<) than 15 are displayed on the screen. N.B. Press <F3> to see a listing of all variables in the current database file.

c. List selected variables

LIST variable1 variable2 ...

After issuing this command, a listing of the values of certain variables (variable1, variable2, ...) will be displayed on the screen. For example, LIST ATS GCS. For each record, this displays a listing of the Adult Trauma Score (ATS) and the Glasgow Coma Scale (GCS).

d. Frequency of selected variables

FREQ variable1 variable2 ...

This displays the frequency, percentage, and cumulative percentage of the variables listed after the freq-command. For example, type in FREQ ATS GCS.

e. Directing output

Output can be directed to either to the printer (press <F5>), the screen (press <F5> again) or to a file. The output goes to the screen if no commands are issued. In addition to pressing <F5>, the following commands can be typed in:

ROUTE PRINTER

ROUTE SCREEN

ROUTE filename

Issue these commands or press <F5> before any output is created.

III. UTILITIES

The third option of the main menu are the system utilities which consists of the options: a. Facility Information, b. Transfer Records, and c. Export State Mandated Reports.

A. Facility information

This option can be used to set default values (initial settings) for the operation of the RISS-system. The following screen will be displayed upon selection of the Facility Information from the main menu.

Facility ID Number	_____
Facility Name:	_____
Patient Look-up Preference	<input type="text" value="Name"/>
Display options upon entering fields?	_
Default City:	_____
Default County:	_____
Default State:	__
Default Zip:	____-____
Automatic ER Log Number:	_
Next ER Log Number:	_____

Facility ID Number: Each hospital is identified by a unique number; the Facility ID Number which is set by the RISS data management team.

Facility Name: The Name of the facility using the RISS-system. This will be displayed on the screen when starting the system.

Patient Look-up Preference: This field determines which field the cursor goes to when the user is asked for the patient's last name, first name, social security number, and hospital ID number in the window which will be displayed when Adding a new ER record or Modifying an existing ER Record. The patient look-up preference comes into effect after rebooting the computer by simultaneously pressing <Ctrl><Alt>.

Display options upon entering fields: The list with predetermined categories for certain fields can either be displayed on the screen upon entering the field (enter Y for Yes) or when a wrong letter or number has been made entered (enter N for No)

Default City: The initial setting of the patient's city of residence.

Default County: The initial setting of the patient's county of residence.

Default State: The initial setting of the state the patient resides in.

Default Zip: The initial setting of the patient's zip-code.

Automatic ER Log Number: The computer can assign a unique, sequential log number to each patient's visit (enter Y) or the user can type in unique log number upon entering the ER Log # field.

Next ER Log Number: The starting value of the ER Log number when the computer automatically assigns a unique, sequential number to each patient's visit.

B. Transfer RISS-records

By selecting this option of the Utilities-menu, the recently collected data as well as data that has recently been modified will be stored on diskette and send to the data management office.

Address: Mario Schootman
University of Iowa
Injury Prevention Research Center
Oakdale Campus
Iowa City, IA 52242

C. Export State Mandated Reports

By choosing this option of the Utilities-menu, the Farm Injury Report, Brain/Spinal Cord Injury Form can be saved onto diskette by specifying specific dates. The information can be stored to either the A or B diskette drive. The Mini-Dawn form and the COBRA form can be printed out by specifying dates. After saving the data for the Farm Injury Report and the Brain/Spinal Cord Injury Form to diskette and printing out the other two state mandated form, they can be send to the Iowa Department of Public Health.

APPENDIX 1. STANDARD INDUSTRIAL CODES

The Standard Industrial Codes (SIC) consist of a number of different levels of codes of which we will use only two. The first level is the level printed in uppercase letters on this page. After selecting an entry from the first level, the second screen will be displayed on the computer based on the selection made by the user. The second level is displayed in lower case letters. From that screen the user will select the second and also final code. Some groups of industries may not have a second level. Several examples of industries listed on the second level will be given.

The code of a particular industry may also entered directly into the RISS-system without looking up the description.

A AGRICULTURE, FORESTRY, AND FISHING

- 01 Agricultural production -crops
- 02 Agriculture production livestock and animal specialties
- 07 Agricultural services
- 08 Forestry
- 09 Fishing, hunting, and trapping

B MINING

- 10 Metal Mining
- 12 Coal mining
- 13 Oil and gas extraction
- 14 Mining and quarrying of nonmetallic minerals, except fuels

C CONSTRUCTION

- 15 Building construction -general contractors and operative builders
- 16 Heavy construction other than building construction -contractors
- 17 Construction -special trade contractors

D MANUFACTURING

- 20 Food and kindred products
- 21 Tobacco products
- 22 Textile mill products
- 23 Apparel and other finished products made from fabrics and similar materials
- 24 Lumber and wood products, except furniture
- 25 Furniture and fixtures
- 26 Paper and allied products
- 27 Printing, publishing, and allied industries
- 28 Chemicals and allied products
- 29 Petroleum refining and related industries
- 30 Rubber and miscellaneous plastics products
- 31 Leather and leather products
- 32 Stone, clay, glass, and concrete products
- 33 Primary metal industries
- 34 Fabricated metal products, except machinery and transportation equipment
- 35 Industrial and commercial machinery and computer equipment

- 36 Electronic and other electrical equipment and components, except computer equipment
- 37 Transportation equipment
- 38 Measuring, analyzing, and controlling instruments; photographic, medical and optical goods; watches and clocks
- 39 Miscellaneous manufacturing industries

E TRANSPORTATION, COMMUNICATION, ELECTRIC, GAS, AND SANITARY SERVICES

- 40 Railroad transportation
- 41 Local and suburban transit and interurban highway passenger transportation
- 42 Motor freight transportation and warehousing
- 43 United States Postal Services
- 44 Water transportation
- 45 Transportation by air
- 46 Pipelines, except natural gas
- 47 Transportation services
- 48 Communications
- 49 Electric, gas, and sanitary services

F WHOLESALE TRADE

- 50 Wholesale trade -durable goods
- 51 Wholesale trade -nondurable goods

G RETAIL TRADE

- 52 Building materials, hardware, garden supply, and mobile home dealers
- 53 General merchandise stores
- 54 Food stores
- 55 Automotive dealers and gasoline service stations
- 56 Apparel and accessory stores
- 57 Home furniture, furnishings, and equipment stores
- 58 Eating and drinking places
- 59 Miscellaneous retail

H FINANCE, INSURANCE, AND REAL ESTATE

- 60 Depository institutions
- 61 Nondepository credit institutions
- 62 Security and commodity brokers, dealers, exchanges, and services
- 63 Insurance carriers
- 64 Insurance agents, brokers, and service
- 65 Real estate
- 67 Holding and other investment offices

I SERVICES

- 70 Hotels, rooming houses, camps, and other lodging places
- 72 Personal services
- 73 Business services
- 75 Automotive repair, services, and parking
- 76 Miscellaneous repair services
- 78 Motion pictures
- 79 Amusement and recreation services
- 80 Health services

- 81 Legal services
- 82 Educational services
- 83 Social services
- 84 Museums, art galleries, and botanical and zoological gardens
- 86 Membership organizations
- 87 Engineering, accounting, research, management, and related services
- 88 Private households
- 89 Miscellaneous services

J PUBLIC ADMINISTRATION

- 91 Executive, legislative, and general governmental, except finance
- 92 Justice, public orders, and safety
- 93 Public finance, taxation, and monetary policy
- 94 Administration of human resource programs
- 95 Administration of environmental quality and housing programs
- 96 Administration of economic programs
- 97 National security and international affairs

K NONCLASSIFIABLE ESTABLISHMENTS

L UNKNOWN

APPENDIX 2. STANDARD OCCUPATIONAL CODES

The Standard Occupational Codes (SOC) consist of a number of different levels of codes of which we will use only two. The first level is the level printed in uppercase on this page. After selecting an entry from the first level, the second screen will be displayed on the computer based on the selection made by the user. The second level is displayed in lower case letters on this page. From that screen the user will select the second which is also the final code. Some groups of occupations may not have a second level. Several examples of occupations listed on the second level will be given.

The code of a particular occupation may also entered directly in the RISS-system without looking up the description.

- 1 EXECUTIVE, ADMINISTRATIVE, AND MANAGERIAL OCCUPATIONS
 - 11 Officials and administrators, public administration
(e.g., Human Resources programs administrators, Public Finance, Judicial and Public Safety)
 - 12, 13 Officials and administrators, other
 - 14 Management related occupations

- 2 ENGINEERS, SURVEYORS AND ARCHITECTS

- 3 NATURAL SCIENTISTS AND MATHEMATICIANS
 - 17 Computer, mathematical, and operations research occupations
 - 18 Natural scientists

- 4 SOCIAL SCIENTISTS, SOCIAL WORKERS, RELIGIOUS WORKERS, AND LAWYERS
 - 19 Social scientists and urban planners
 - 20 Social, recreation, and religious workers
 - 21 Lawyers and judges

- 5 TEACHERS, LIBRARIANS, AND COUNSELORS
 - 22 Teachers, colleges, university and other postsecondary institution
 - 23 Teachers, except postsecondary institution
 - 24 Vocational and educational counselors
 - 25 Librarians, archivists, and curators

- 6 HEALTH DIAGNOSING AND TREATING PRACTITIONERS
 - 26 Physicians and dentists
 - 27 Veterinarians
 - 28 Other health diagnosing and treating practitioners

- 7 REGISTERED NURSES, PHARMACISTS, DIETITIANS, THERAPISTS, AND PHYSICIAN'S ASSISTANTS
 - 29 Registered nurses
 - 30 Pharmacists, dietitians, therapists, and physician's assistants

- 8 WRITERS, ARTISTS, ENTERTAINERS, AND ATHLETES
 - 32 Writers, artists, performers, and related workers
 - 33 Editors, reporters, public relation specialists, and announcers

34 Athletes and related workers

9 HEALTH TECHNOLOGISTS AND TECHNICIANS

10 TECHNOLOGISTS AND TECHNICIANS, EXCEPT HEALTH

37 Engineering and related technologists and technicians

38 Science technologists and technicians

39 Technicians; except health, engineering, and science

11 MARKETING AND SALES OCCUPATIONS

40 Supervisors, marketing and sales occupations

41 Insurance, securities, real estate, and business service sales occupations

42 Sales occupations, commodities except retail

43 Sales occupations, retail

44 Sales related occupations

12 ADMINISTRATIVE SUPPORT OCCUPATIONS, INCLUDING CLERICAL

45 Supervisors; administrative support occupations, including clerical

46, 47 Administrative support occupations, including clerical

13 SERVICE OCCUPATIONS

50 Private household occupations

51 Protective service occupations

52 Service occupations, except private household and protective

14 AGRICULTURAL, FORESTRY, AND FISHING OCCUPATIONS

55 Farm operators and managers

56 Other agricultural and related occupations

57 Forestry and logging occupations

58 Fishers, hunters, and trappers

15 MECHANICS AND REPAIRERS

60 Supervisors; mechanics and repairers

61 Mechanics and repairers

16 CONSTRUCTION AND EXTRACTIVE OCCUPATIONS

63 Supervisors; construction and extractive occupations

64 Construction trades

65 Extractive occupations

17 PRECISION PRODUCTION OCCUPATIONS

67 Supervisors; precision production occupations

68 Precision production occupations

69 Plant and systems operators

18 PRODUCTION WORKING OCCUPATIONS

71 Supervisors; production occupations

73, 74 Machine setup operators

75, 76 Machine operators and tenders

77 Fabricators, assemblers, and hand working occupations

78 Productive inspectors, testers, samplers, and weighers

19 TRANSPORTATION AND MATERIAL MOVING OCCUPATIONS
81 Supervisors; transportation and material moving occupations
82 Transportation occupations
83 Material moving occupations, except transportation

20 HANDLERS, EQUIPMENT CLEANERS, HELPERS, AND LABORERS
85 Supervisors; handlers, equipment cleaners, helpers and laborers
86 Helpers
87 Handlers, equipment cleaners and laborers

21 MILITARY OCCUPATIONS

22 MISCELLANEOUS OCCUPATIONS

23 UNKNOWN

APPENDIX 3. PREDETERMINED CATEGORIES and HOT KEYS

Field Name	Predetermined Categories	Hot Key
Sex	Male	M
	Female	F
	Unknown	U
Race	White, non-Hispanic	W
	Black, non-Hispanic	B
	American Indian/Eskimo/Aleut	A
	Asian or Pacific islander	S
	Hispanic	H
	Other race	O
Unknown	U	
Marital Status	Married	M
	Never married	N
	Widowed	W
	Divorced	D
	Separated	S
Unknown	U	
Respiratory Rate	10-29 times per minute	4
	More than 29 times per minute	3
	6-9 times per minute	2
	1-5 times per minute	1
0 times per minute	0	
Best Motor Response	Purposeful movement on command	6
	Localization of pain	5
	Withdrawal from pain	4
	Extremity flexion with painful stimulus ...	3
	Extremity extension with painful stimulus .	2
No response	1	
Best Verbal Response	Well-oriented conversation	5
	Words or phrases	4
	Incomprehensible vocal sounds	3
	Grunts	2
Mo response	1	
Eye Opening	Spontaneous	4
	To voice	3
	To pain	2
	No response	1

Place of Occurrence	Home	H
	Farm	F
	Mine & quarry	M
	Industrial place & premises	I
	Place for recreation & sport	S
	Street & highway	G
	Public building	P
	Residential institution	R
	Other	O
Unspecified place	U	
Intentional	Intentional	I
	Suspected	S
	Unintentional	U
EMS Code	Ground ambulance	G
	Rotor air ambulance	R
	Fixed wing ambulance	F
	Public safety vehicle (non ambulance)	P
	Private vehicle	V
	Walk-in	W
	Other	O
Unknown	U	
Provider Code	Physician	P
	Nurse	N
	Nurse Practitioner	A
	Physician's assistant	U
Within City Limits		
Injury		
BP, Resp, Neuro Normal		
Work Related		
Brain Spinal Cord Injury		
Farm Related		
Substance Abuse		
	Yes	Y
	No	N
	Unknown	U

APPENDIX 4. DATABASES, VARIABLE NAMES, AND LINKAGE VARIABLES

Database: PATDEMO.DBF

Variable Name	Description
plname:	Last name
pfname:	First name
pmname:	Middle initial
dob:	Date of birth
sex:	Gender
martstatus:	Marital status
race:	Race
patphone:	Phone number
adurbanloc:	Place of residence within city limits
patstreet:	Street address
patcounty:	County of residence
patcity:	City of residence
patcountry:	Country of residence
patstate:	State of residence
patzip:	Zip code of the place of residence
empindust:	Type of industry
empicode:	Standard Industrial Code
empjob:	Type of occupation
empocode:	Standard Occupational Code
empname:	Employer name
empstreet:	Employer street address
empcity:	Employer city
empstate:	Employer state
empzip:	Employer zip code
rellname:	Contact person's last name
relfname:	Contact person's first name
relmname:	Contact person's middle initial
relationsh:	Relationship of the contact person to the patient
relphone:	Phone number of the contact person
relstreet:	Street address of the contact person
relcity:	City of residence of the contact person
relstate:	State of residence of the contact person
relzip:	Zip code of the place of residence of the contact person
recdate:	Date of last modification
rectime:	Time of last modification
Linkage variable:	
ssn:	Social security number

Database: VISITINF.DBF

Variable Name	Description
hospid:	The patient's hospital identification number
datein:	Date the patient came to the ER
timein:	Time the patient came to the ER
erlgnum:	ER lognumber
reasonvis:	Reason for visit
injury:	Injury-related diagnosis
dateonset:	Date of onset of the complaint
timeonset:	Time of onset of the complaint
addressinj:	Location of the injury
atsnormal:	Bp, Respiratory function, and neurologic exam normal
sysbp:	Systolic blood pressure
resprate:	Respiratory rate
ats:	Adult Trauma Score
bestmotres:	Best motor response
bestverres:	Best verbal response
eyeopening:	Eye opening
gcs:	Glascow Come Scale
ecode_1:	External Cause code 1
ecode_2:	External Cause code 2
ecode_3:	External Cause code 3
ecode_4:	External Cause code 4
placeoccur:	Palce of injury occurrence
urbanloca:	Injury occurrence within city limits
intention:	Injury intentional
workrelat:	Injury work-related
brainspine:	Brain/spinal cord injury
farmrelat:	Injury farm-related
substabase:	Substance abuse
ssn:	Social security number
visit:	Number of visits
recdate:	Date of last modification
rectime:	Time of last modification

Linkage variable: erlgnum

Database: ARRIVAL.DBF

Variable Name	Description
-----	-----
hospid:	Patient's hospital identification number
ssn:	Social security number
indate:	Visit date
emscode:	Mode of arrival
emsidnum:	Identification number of ambulance
emsrnum:	Run number of the ambulance
emscname:	EMS company name
visit:	Number of visits
recdate:	Date of last modification
rectime:	Time of last modification

Linkage variable:

erlgnum:	ER lognumber
----------	--------------

Database: DISPOSIT.DBF

Variable Name	Description
-----	-----
hospid:	Patient's hospital identification number
ssn:	Social security number
indate:	Visit date
ncode_1	Diagnosis code 1 of the complaint
ncode1desc	Diagnosis description of the complaint
ncode_2	Diagnosis code 2 of the complaint
ncode3desc	Diagnosis description of the complaint
ncode_3	Diagnosis code 3 of the complaint
ncode3desc	Diagnosis description of the complaint
ncode_4	Diagnosis code 4 of the complaint
ncode4desc	Diagnosis description of the complaint
dispositio:	Disposition
visit:	Number of visits
recdate:	Date of last modification
rectime:	Time of last modification

Linkage variable:

erlgnum:	ER lognumber
----------	--------------

Database: PRIMPROV.DBF

Variable Name	Description
hospid:	Patient's hospital identification number
ssn:	Social security number
datein:	Visit date
providcode:	Provider code
providnum:	Provider number
providname:	Provider name
consult_1:	Consultant 1
consult_2:	Consultant 2
consult_3:	Consultant 3
consult_4:	Consultant 4
consult_5:	Consultant 5
consult_6:	Consultant 6
consult_7:	Consultant 7
consult_8:	Consultant 8
consult_9:	Consultant 9
consult_10:	Consultant 10
visit:	Number of visits
recdate:	Date of last modification
rectime:	Time of last modification
Linkage variable:	
erlgnum:	ER lognumber

TAB 2

APPENDIX 2

ICD Codes for Musculoskeletal Disorders that Result from
Chronic Exposure

ICD Codes for Musculoskeletal Disorders that Result
from Chronic Exposures

The range of ICD categories that were considered as possibly containing musculoskeletal disorders that could have resulted from chronic exposures were the following: 350-359; 710-739; and 840-848. The following is a listing of the three-digit codes within this range with a notation for each as to whether to exclude the category as not being relevant, whether to include it, and if so, whether most of the specific diagnoses within the category, or only some of them, would likely result from chronic exposures.

ICD Code	Diagnostic Category	Status (M)= Most (S)= Some
350	Trigeminal nerve disorders	Exclude
351	Facial nerve disorders	Exclude
352	Disorders of other cranial nerves	Exclude
353.0	Brachial plexus lesions	Include
Other 353	Other nerve root and plexus disorders	Exclude
354	Mononeuritis of upper limb & mononeuritis multiplex	Include (M)
355	Mononeuritis of lower limb	Include (S)
356	Hereditary and idiopathic peripheral neuropathy	Exclude
357	Inflammatory and toxic neuropathy	Exclude
358	Myoneural disorders	Exclude
359	Muscular dystrophies and other myopathies	Exclude
710	Diffuse diseases of connective tissue	Exclude
711	Arthropathy assoc. with infections	Exclude
712	Crystal arthropathies	Exclude
713	Arthropathy assoc. with other disorders classified elsewhere	Exclude
714	Rheumatoid arthritis and other inflammatory polyarthropathies	Exclude
715	Osteoarthritis and allied disorders	Include (M)
716	Other and unspecified arthropathies	Include (S)
717	Internal derangement of knee	Include (M)

ICD Code	Diagnostic Category	Status (M) = Most (S) = Some
718	Other derangement of joint	Include (S)
719	Other and unspec. disorders of joint	Include (S)
720	Anklyosing spondylitis and other inflam. spondylopathies	Exclude
721	Spondylosis and allied disorders	Include (M)
722	Intervertebral disc disorders	Include (M)
723	Other disorders of cervical region	Include (S)
724	Other and unspec. disorders of back	Include (M)
725	Polymyalgia rheumatica	Exclude
726	Periph al enthesopathies	Include (M)
727	Other disorders of synovium, tendon, and bursa	Include (S)
728.6	Contracture of palmar fascia	Include
Other 728	Other disorders of muscle, ligament, and fascia	Exclude
729	Other disorders of soft tissue	Exclude
730	Osteomyelitis, periostitus and other infections involving bone	Exclude
731	Osteitis deformans and osteopathies assoc. with oth. disorders classified elsewhere	Exclude
732	Osteochondropathies	Exclude
733	Other disorders of bone and cartilage	Exclude
734	Flat foot	Exclude
735	Acquired deformities of toe	Exclude
736	Other acquired deformities of limbs	Exclude
737	Curvature of spine	Exclude
738	Other acquired deformity	Exclude
739	Nonallopathic lesions, NEC	Exclude
840	Sprains and strains of shoulder and upper arm	Include (M)
841	Sprains and strains of elbow and forearm	Include (M)

ICD Code	Diagnostic Category	Status (M) = Most (S) = Some
842	Sprains and strains of wrist and hand	Include (M)
843	Sprains and strains of hip abd thigh	Include (M)
844	Sprains and strains of knee and leg	Include (M)
845	Sprains and strains of ankle and foot	Include (M)
846	Sprains and strains of sacroiliac region	Include (M)
847	Sprains and strains of other and unspec. parts of back	Include (M)
848	Other and ill-defined sprains and strains	Exclude

TAB 2

APPENDIX 3

CPWR's: Work-Related Musculoskeletal Disorders: A
Construction Bibliography

The Center to Protect Workers' Rights

Work-Related Musculoskeletal Disorders: A Construction Bibliography

Prepared by:
University of Iowa
July 17, 1993

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PREFACE

The focus of this bibliography is on construction work and work-related musculoskeletal disorders. The scope comes primarily from the biomedical, industrial hygiene, and ergonomic literature available through such online and CD-ROM bibliographic databases as The National Library of Medicine's MEDLARS system of databases, The National Institute for Occupational Health and Safety Technical Information Center's (NIOSHTIC) database, and Excerpta Medica. Bibliographic citations from authors have also supplied a number of the research articles, particularly for some of the construction related research. The Center to Protect Workers' Rights has provided a number of the citations in the bibliography. The majority of the research collected here is available from reviewed journals as part of the scholarly communication system.

Primary access to the research represented in this bibliography is through the construction work performed. All construction related citations are placed under the relevant work category. Here the user of the bibliography can gain an idea of what is known about the risk, or job factors, and health outcomes for those who work in the construction trades. There is obviously very little research on many of the trades and the tasks they must perform.

Additional citations from the wider universe of research on work-related musculoskeletal disorders are located under the region or nature of the disorder, and in the appropriate ergonomic categories.

Many of the abstracts are those supplied by the authors and available through the National Library of Medicine's Medline database, or entered from the article abstract. For journals not indexed by Medline or without author abstracts, the abstracts provided through NIOSHTIC's CD-ROM have been used and are so noted. The annotations for the Bygghalsan Bulletin abstracts highlight some of the findings of the Swedish research these English abstracts report.

WORK-RELATED MUSCULOSKELETAL DISORDERS: A CONSTRUCTION BIBLIOGRAPHY

BIOMARKERS OF MUSCULOSKELETAL DISEASE

Mastin, J.; Henningsen, G.; Fine, L. Use of biomarkers of occupational musculoskeletal disorders in epidemiology and laboratory animal model development. *Scandinavian Journal of Work, Environment & Health*. 1992; 18(Suppl 2): 85-87. Note: NIOSH Abstract.

The possibility that biomarker technology could be used to detect occupational musculoskeletal disease at an early, preclinical stage and allow intervention methods to be taken prior to irreversible damage occurring was discussed. Four types of biomolecules have been investigated as potential biomarkers of musculoskeletal disease: proteins that are constituents of musculoskeletal tissue and either released through catabolic processes or produced as part of the repair process; proteins associated with the inflammatory response; preinflammatory response biomolecules; and indicators of immune mediated inflammatory processes. While most musculoskeletal biomarkers are not specific for a particular disorder, they can be compatible with and aid in supporting the presence and extent of disease when used as part of a profile of appropriate tests and accurate work histories. Research in this area was being conducted to identify biomarkers of the early stages of experimental progressive joint disease in two animal models. Preliminary results have identified four potential biomarkers for immobilization-induced joint disease: haptoglobin, beta2-microglobulin, cartilage matrix glycoprotein, and a 25 kilodalton glycoprotein.

BRICKLAYING

Akinmayowa, N. Reducing repetitive strain and back pain among bricklayers. P. Buckle (Ed.). *Musculoskeletal Disorders at Work: Proceedings of a Conference Held at The University of Surrey, Guildford 13-15 April 1987*. London: Taylor & Francis; 1987: 189- 93.

Note: NIOSH Abstract.

Health problems of bricklayers working in hot and humid environments were studied. Medical records on the prevalence of musculoskeletal problems were reviewed for over 6,500 men in Nigeria. A random selection of 1500 subjects was made for sampling by a questionnaire designed to evaluate job factors affecting worker health. Three groups of 60 bricklayers who suffered significantly higher prevalence of musculoskeletal problems were selected for task analysis. Each individual group was studied once a week for a total of 7 weeks. Musculoskeletal problems affected 97 percent of the bricklayers studied. The severity of the disorders increased with age. Bricklayers over 27 years of age reported serious disorders of lower back pain and repetitive pain of the lumbar region. For workers over 43 years of age, the disorder involved regular pain every day requiring

BRICKLAYING

medication or absence from work. In 80 percent of the subjects a loss of sensitivity of touch in the finger was the major problem they reported. Rural bricklayers had a significantly higher prevalence of musculoskeletal problems than urban workers. Much of the problem arose from environmental heat stress. The authors suggest that ergonomic principles be used in planning rest periods, structuring work and scheduling.

Binkhorst, R. The physiological load of bricklaying. W. Rohmert & H. Wenzel (Eds.). *Studies in Industrial & Organizational Psychology*, Vol. 8. Different Aspects of Performance. Frankfurt: Peter Lang; 1989: 256-59.

The aim of this part of the study was to assess the physiological load of bricklaying in housebuilding. A group of young and a group of older bricklayers were studied by means of time and motion studies, oxygen consumption measurements and heart rate recordings. The maximal oxygen uptake was determined by means of arm ergometry. The subjective judgement of the bricklayers confirmed the physiological findings: they preferred to have the mortar barrel and the pile of bricks on the level of 30 cm.

Hammarskjöld, E. Blocks and bricks of masonry -- weight recommendations -- a new Swedish standard. *Bygghalsan Bulletin*. 1987-05-01.

Note: English Abstract.

An abstract on the new Swedish weight recommendations for masonry blocks and bricks. Ordinary bricks, intended to be handled with one hand, should not weigh more than 3 kg. If they weigh more than 3 kg, they are by definition called blocks and must be handled with two hands. If they weigh between 12 and 20 kg, the bricklayer is supposed to handle them only between knee and shoulder level, and the scaffolding must be designed accordingly. Blocks weighing more than 20 kg shall be handled by lifting equipment, e.g., vacuum lifts, small vault cranes or similar devices.

Jäger, M.; Luttmann, A.; Laurig, W. Lumbar load during one-handed bricklaying.

International Journal of Industrial Ergonomics. 1991; 8: 261-77.

Lumbar load, as indicated by the moment of force and the force at the lumbosacral disc, was determined for one-handed bricklaying tasks using a dynamic 3-D model, 'The Dortmund'. The grasp height differed (90, 50, 10 cm). By contrast, the final postures were assumed almost upright in all cases. This resulted in considerable variance in the postures during the computer-simulated movements. The task duration varied (2.0, 1.5, 1.0 s). The lower the grasp height and the shorter the time, the higher the lumbar load (movement of force at L5-S1 up to 140 Nm, compressive force up to 6 kN), and the larger the differences between dynamic and static calculations. Increasing brick mass (0, 5, 10 kg) leads to an upward shift in the moment and compression curves (20 Nm or 1 kN per 5 kg). For the assessment of lumbar load during the analysed bricklaying tasks, the lumbosacral moment of force was first classified according to Tichauer (1978). Bricklaying involving a 50 cm grasp height requires 'selection of labor, careful training and rest pauses'. Lower grasp heights or bricks of 10 kg should not occur throughout 'the entire working day'. Lumbosacral force was then compared with lumbar strength values provided in the literature. These vary within a wide range (0.8-13 kN). Strength mean +/- s.d. amounts to 5.0 +/- 2.2 kN for the total sample (n = 507), to 5.8 +/- 2.6 kN for males (n = 174) and to 4.0 +/- 1.5 kN for females (n = 132). Strength depends primarily on age. Assuming linear regression models, strength (in kN) is 10.53-0.97/decade for males ($r^2 = 0.39$) and 7.03-0.59/decade for females ($r^2 = 0.35$). A strength prediction model considering 3 additional factors was developed ($r^2 = 0.62$) in order to explain

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most of the remaining variance. Since average values may overestimate an individual's strength, the mean or regression model value should be reduced by the s.d. of the respective sample. This would result in a lumbar load limit of 5.5 kN for 25-year-old and 2.6 kN for 55-year-old-men. Corresponding values for women are 4.1 and 2.3 kN. If the brick-supply stack is 90 cm high, the lumbar load limits will not be exceeded for any person in these age groups. By contrast, all limits would be exceeded for a 10-kg 1-s brick transfer from a grasp height of 10 cm. In conclusion, to ensure that the predicted lumbar load during bricklaying remains below the limits, the brick-supply stack should be above 50 cm. This paper provides a biomechanical determination and assessment of the load on the lumbar spine during bricklaying tasks with different grasp heights. Bricks should be pre-positioned to permit grasping in erect postures.

- Jorgensen, K.; Jensen, B.; Kato, M. Fatigue development in the lumbar paravertebral muscles of bricklayers during the working day. *International Journal of Industrial Ergonomics*. 1991; 8: 237-45.
- Bricklayer work is characterized by repetitive flexions and extensions of the trunk and many possibly harmful working positions. The aim of this study was to investigate whether the fatigability of the trunk extensors was changed during the working day in a group of bricklayers. Eight healthy male bricklayers participated in the study. During the working day HR and lumbar back RPE was monitored. The overall HR was 91. HR and RPE increased significantly from the start of the working day to noon from 84 to 95 and 2.1-3.9, respectively. No changes occurred in HR and RPE during the afternoon. The isometric endurance of the trunk extensors at 30% MVC measured prior to and at the end of the working day decreased significantly from 4.88 min to 3.99 min. The trunk extensor strength measured 5-10 s after the end of the endurance experiment was reduced to the same level both before and after the working day. During the working day three standardized 90 seconds isometric 30% MVC trunk extensor contractions were performed: before beginning the work, before lunch and immediately after the end of the working day. During the test contractions the following recordings were obtained: Bilateral surface EMG from the lumbar part of the trunk extensors (L3), heart rate (HR), blood pressure (BP) and rate of perceived exertion (RPE: 0-10) from the paravertebral muscles. The EMG-MSF (mean spectral frequency) from test contractions (left muscle portion) decreased significantly from 139 to 129 during the day. The RPE showed a significant increase of approximately 2 from the morning to the lunch break. No significant changes occurred in HR and BP during the working day. In conclusion: this investigation shows that the contraction pattern of the paravertebral muscle in bricklayers performing facing the wall building may lead to muscular fatigue during the working day. [The authors urge that profound ergonomic and organizational changes be made in the work activities of bricklayers.]
- Kopf, T.; Von Feder, T.; Karmaus, W. Risks for musculo-skeletal disorders of the low back, the shoulders, the elbows, and the wrists in bricklayers. C. Hogstedt; & C. Reuterwall (Eds.). *Progress in Occupational Epidemiology: Proceedings of the Sixth International Symposium on Epidemiology in Occupational Health*, Stockholm, Sweden, 16-19 August 1988. Amsterdam: Elsevier Science Publishers B.V.; 1988: 219-22.
- A study of bricklayers (N = 250) using a self-reported questionnaire. Logistic regression analyses revealed high relative risk estimates (OR) for pain in the joints of the left upper limb such as wrist, elbow and shoulder for bricklayers. The job demand index (consisting of the items heavy physical work, awkward working positions, repetitive movements and restriction in the standing posture) was a

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significant predictor for such pain. The authors' conclude that this indicates an over-use and overload of the left upper limb by bricks that are too heavy for use by humans. Estimations of the 'Attributable Risk Proportion %' based on the Odds-Ratio from the logistic regressions show that 81 percent of the pain in the left wrist in the study population can be explained just by being a bricklayer.

Luttmann, A.; Jager, M.; Laurig, W. Task analysis and electromyography for bricklaying at different wall heights. *International Journal of Industrial Ergonomics*. 1991; 8: 247-60.

Work-sequence and posture analyses were performed in a field study on bricklaying. The study reveals that, for low walls, the bricklayers spend up to 75% of the total duration of the activity in an inclined posture, this percentage decreasing with wall height to between 20 and 25%. Where wall levels are below 100 cm, a load (brick) is held in one hand for approx. 30% and a load in both hands (brick, trowel and mortar) for 13% of the time. The percentages increase for higher walls to 45 and 30% respectively. The number of bricks laid per unit of time decreases with increasing wall height from about 2.7 bricks/min for a 20 cm wall to about 2.0 bricks/min for a 160 cm wall. The field study was supplemented by electromyographical laboratory investigations. These reveal that, with increasing wall height, the myoelectrical activity of the back musculature and of the left biceps muscle rises to a multiple of the activity for low walls. Workplace-design proposals were derived from the findings of the field and laboratory investigations under consideration of studies taken from the literature on the stress on the skeletal and cardiopulmonary systems. Accordingly, the scaffold should be frequently adapted to the wall height, thus excluding both low and high wall levels. In addition, the brick and mortar supplies should be arranged to allow the bricklayers to grasp them without bending down. The paper provides a work-sequence and posture analysis of bricklaying on the basis of field studies and a laboratory investigation into muscle strain during bricklaying. In addition, it makes recommendations for the work design of bricklaying.

Malchaire, J.; Rezk-Kallah, B. Evaluation of the physical work load of bricklayers in the steel industry. *Scandinavian Journal of Work, Environment & Health*. 1991; 17(2): 110-16.

A study was made of work conditions suspected of being responsible for a greater prevalence of musculoskeletal disorders among 33 bricklayers. A standardized questionnaire was used to confirm a high 12-month prevalence of 73% for the low back and about 20% for the upper limbs. Physical work load was studied with the use of heart rate recordings and posture analyses. According to the heart rate data, the work load was "moderately heavy" (300 W). A diagnostic analysis identified work postures that could be considered as imposing a heavy strain on the musculoskeletal system. The risk associated with these postures was investigated with biomechanical models. This analysis procedure made possible elaborate ergonomic solutions that reduced the work load in general and the biomechanical constraints in particular.

Schneider, S. Observations on ergonomic hazards at the IAM worksite. (Unpublished Paper, 1991). 3 pages.

Observations on the hazards encountered in the course of iron work, concrete work, and masonry work. Includes solutions and suggestions for ergonomic improvements.

Stenlund, B.; Goldie, I.; Hagberg, M.; Hogstedt, C.; Marions, O. Radiographic osteoarthrosis in the acromioclavicular joint resulting from manual work or

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exposure to vibration. *British Journal of Industrial Medicine*. 1992; 49(8): 588-93. The hypothesis that manual work and exposure to vibration are antecedents to the development of osteoarthritis was assessed employing a cross sectional study design. The frequency of osteoarthritis in the acromioclavicular joint was studied in three groups of workers in the construction industry. Two groups were manual workers (54 bricklayers and 55 rock blasters); the third group consisted of 98 foremen. The radiographic appearance of the right and left acromioclavicular joints was classified into one of five grades of osteoarthritis. A protocol was developed to assess exposure on the basis of job title, years of manual work, total weight lifted during working life, and total hours of exposure to vibrating tools. Odds ratios for job titles (manual worker v foreman) and for years of manual work as indicators of exposure were of similar magnitude of around 2.5. Construction workers who had lifted more than 709 tonnes had an increased risk of developing severe osteoarthritis of the right acromioclavicular joint, odds ratio: 2.62 (95% confidence interval (95% CI), 1.13-6.06). The odds ratio for the left side was 7.67 (95% CI, 2.76-21.34). In the analysis of vibration exposure, workers who had been highly exposed to vibration had an odds ratio of 1.99 (95% CI, 1.00-3.92) on the right side and 2.20 (95% CI, 1.07-4.56) on the left. This effect almost disappeared after simultaneous adjustment for manual work. Occupational and ergonomic factors, such as the sum of lifted tonnes during working life, job title, and the sum of years of manual work seem to be risk factors for osteoarthritis of the acromioclavicular joint, whereas vibration alone was a weaker risk factor.

Stenlund, B.; Goldie, I.; Hagberg, M.; Hogstedt, C. Shoulder tendinitis and its relation to heavy manual work and exposure to vibration. *Scandinavian Journal of Work Environment & Health*. 1993; 19: 43-49.

Three categories of construction industry workers (54 bricklayers, 55 rockblasters, and 98 foremen) were compared in a cross-sectional study. In a structured interview they reported exposure to loads lifted, vibration, and years of manual work. They were also subjected to a clinical investigation including medical history and a detailed shoulder examination. Among the rockblasters 33% had signs of tendinitis in the left and 40% in the right shoulder. Among the bricklayers and foremen 8-17% had signs of shoulder tendinitis. In a multiple logistic regression being a rockblaster compared with being a foreman showed an odds ratio (OR) of 3.33 for left-sided and 1.71 for right-sided shoulder tendinitis. Vibration exposure yielded an OR of 1.84 and 1.66 for the left and right sides, respectively. Vibration exposure or work as a rockblaster seemed to be risk indicators for tendinitis of the shoulders.

Vink, P.; Koningsveld, E. Bricklaying: a step by step approach to better work. *Ergonomics*. 1990; 33(3): 349-52.

This study concerns a development towards a feasible improvement in the working conditions of bricklayers. An occupational health survey showed that studies on the magnitude of workload were needed. These studies showed that the energetic workload was 35% for young bricklayers (25-35 years) and 41% for older bricklayers (45-55 years). The most effective improvement is diminishing this workload during the main task, which consumed 58% of the total worktime. An increase or decrease of the work pace had minor effects, but a heightened level of set out pile of bricks and barrel with mortar decreases the energetic workload significantly for the higher brick rows. The experienced workload and biomechanical back stress was also lowest for the higher rows and heightened set out bricks and mortar. Height-adjustable scaffoldings, which enable the bricklayer to put the bricks in the wall in an upright position, should be promoted.

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However, these cannot be used on a large scale and new equipment is now being developed for normal building sites. The implementation of the new working method will be thoroughly prepared in order to optimize its introduction on building sites.

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Armstrong, T.; Castelli, W.; Evans, F.; Diaz-Perez, R. Some histological changes in carpal tunnel contents and their biomechanical implications. *Journal of Occupational Medicine*. 1984; 26(3): 197-201.

The purpose of this study was to investigate the pathological influence of mechanical stresses that occur inside the carpal tunnel during exertions of the hand. Microscopic changes in fibrous tissue density, in synovial, subsynovial, and adjacent connective tissue density, and in median nerve epineurium density, arteriole wall muscle thickness, and arterial and venule endoproliferation were investigated at 5-mm increments along a 9-cm range of six postmortem wrist specimens. All of these changes increased from normal in the proximal portions of the wrist, -30 to -40 mm from the wrist crease, to maximal values 0- to 20-mm distal to the wrist crease. The changes then decreased toward normal in the distal sections, 20 to 40 mm. The location and character of these changes suggest that repeated exertions with a flexed or extended wrist are an important factor in their etiology. The consistency with which they are found in this and other studies suggests that extreme changes associated with highly repetitive work or additional stress factors are required to produce symptoms in most cases of carpal tunnel syndrome.

Armstrong, T.; Chaffin, D. Some biomechanical aspects of the carpal tunnel. *Journal of Biomechanics*. 1979; 12(7): 567-70.

Previously presented evidence indicates that carpal tunnel syndrome is related to compression of the median nerve inside the carpal tunnel. Biomechanical arguments in which the extrinsic finger flexor tendons inside the carpal tunnel are characterized as a frictionless-pulley belt mechanism are presented to show quantitatively how wrist size, wrist position and hand position affect forces on the tendons and their adjacent structures.

Gelberman, R.; Rydevik, B.; Pess, G.; Szabo, R.; Lundborg, G. Carpal tunnel syndrome. A scientific basis for clinical care. *Orthopedic Clinics of North America*. 1988 Jan; 19(1): 115-24.

The series of experimental studies reviewed in this article supports a classification of median nerve compression at the wrist into early, intermediate, advanced, and acute nerve compression. The findings correlate well with experimental studies on the pathophysiology of nerve compression. A patient-specific management approach is recommended based upon the clinical and electrophysiologic findings which can be correlated with previously demonstrated intraneural pathologic changes.

Hagberg, M.; Morgenstern, H.; Kelsh, M. Impact of occupations and job tasks on the prevalence of carpal tunnel syndrome. *Scandinavian Journal of Work, Environment & Health*. 1992; 18(6): 337-45.

In this investigation reported epidemiologic studies on carpal tunnel syndrome (CTS) (15 cross-sectional studies involving 32 occupational or exposure groups and six case-referent studies) were reviewed. The prevalence of CTS in the

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different occupational groups varied between 0.6 and 61%. The highest prevalence was noted for grinders, butchers, grocery store workers, frozen food factory workers, platers, and workers with high-force, high-repetitive manual movements. Odds ratios greater than 10 were reported for exposed groups in three studies. On the basis of epidemiologic and other evidence, it was concluded that exposure to physical work load factors, such as repetitive and forceful gripping, is probably a major risk factor for CTS in several types of worker populations. At least 50%, and as much as 90%, of all of the CTS cases in these exposed populations appeared to be attributable to physical work load. [Electricians, Bleecker et al. 1985 are among the study populations compared.]

Loslever, P.; Ranaivosoa, A. Biomechanical and epidemiological investigation of carpal tunnel syndrome at workplaces with high risk factors. *Ergonomics*. 1993; 36(5):537-54.

This paper deals with the problem of carpal tunnel syndrome (CTS) through investigations of both biomechanical and epidemiological data on seventeen high risk jobs. Biomechanical data were collected from continuous recording of prehension muscular efforts and wrist angular flexion--extension positions for each hand. In order to characterize both static and dynamic behaviours of signals, nine angle and four force indices were built for each hand. The epidemiological data evaluated the probability to contract the CTS (prevalence) on the dominant hand, the non-dominant hand, and both hands simultaneously. Biomechanical and epidemiologic data were evaluated using multiple correspondence factor analysis which may consider heterogeneous variables to clarify non-linear relations in a very large data set. The CTS occurred twice more frequently on the two hands together (average 20%) than on the dominant hand alone. Such a result confirmed the outcome of other studies that non-occupational factors could be more important than occupational factors. The prevalence for both hands was highly correlated with the frequency of flexion and use of high forces. High or low flexions appeared to be a greater risk factor than high or low extensions.

National Institute for Occupational Safety and Health. Carpal Tunnel Syndrome: Selected References. U.S. Department of Health and Public Services; DHHS (NIOSH): Cincinnati, Ohio. 1989.

The National Institute for Occupational Safety and Health (NIOSH) has assembled this packet of information in response to an increasing number of requests regarding carpal tunnel syndrome. This publication is a compilation of selected references describing the results of research conducted or funded by NIOSH, as well as materials from non-NIOSH sources. References included are the NIOSH Congressional Testimony presented before the Subcommittee on Postal Personnel and Modernization, the abstract and table of contents from Cumulative Trauma Disorders: A Manual for Musculoskeletal Diseases of the Upper Limbs (ordering information for the full document is provided), and an excerpt on carpal tunnel syndrome from the Congressional Office of Technology report entitled Preventing Illness and Injury in the Workplace. The remaining articles discuss musculoskeletal and cumulative trauma disorders as well as various aspects of carpal tunnel syndrome, including causes, therapy, ergonomics, and occupational factors.

Silverstein, B.; Fine, L.; Armstrong, T. Occupational factors and carpal tunnel syndrome. *American Journal of Industrial Medicine*. 1987; 11(3): 343-58.
Carpal tunnel syndrome (CTS) is the most commonly reported nerve entrapment syndrome. The prevalence of CTS among 652 active workers in jobs with specific

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hand force and repetitiveness characteristics was estimated. The prevalence of CTS ranged from 0.6% among workers in low force-low repetitive jobs to 5.6% among workers in high force-high repetitive jobs. When controlling for potential confounders, the odds ratio for the high force-high repetitive jobs was more than 15 (p less than .001) compared to the low force-low repetitive jobs. High repetitiveness appears to be a greater risk factor than high force (odds ratio of 5.5 p less than .05 versus 2.9 and not statistically significant).

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Astrand, I.; Guharay, A.; Wahren, J. Circulatory responses to arm exercise with different arm positions. *Journal of Applied Physiology*. 1968; 25(5): 528-32.
The circulatory response to arm exercise by nailing at bench level, into wall at head level, and into ceiling 10 cm above the head was studied in 11 subjects and compared to leg exercise. Oxygen uptake was approximately 1 liter/min for all three types of arm exercise and for 300 kpm/min on a bicycle ergometer. Heart rate, blood pressure, and lactate concentrations during arm exercise were higher for nailing into ceiling than for nailing into wall and bench. In comparison with nailing into bench, bicycle exercise at 300 kpm/min resulted in lower heart rate, blood pressure, and ventilation in relation to oxygen uptake. The diastolic blood pressure during nailing into ceiling was higher than during maximal leg exercise. The observed differences between the hemodynamic responses to arm exercise in different positions indicate an increased sympathetic vasoconstrictor tone for exercise with elevated arms.

Bye, A. Musculoskeletal disorders among employees in building and construction industry. [Norwegian]. *Tidsskrift For Den Norske Laegeforening*. 1991; 111(3): 337-40.
A questionnaire was distributed to 2,696 employees in the construction industry in order to determine the prevalence of subjectively experienced musculoskeletal strain in four regions of the body. A total of 40.3% of the employees had pain at the time of questioning. The percentage of the employees with complaints increases gradually with age, but least for backache. A comparison of different age groups of employees in two occupations reveals that carpenters in the age group 30-40 years have more than ten times as many musculoskeletal disorders in their arms and hands as office workers in the same age group. We presume that more than 90% of these disorders are caused by factors in the working environment. The author concludes that it is important to continuously collect information on musculoskeletal disorders among workers, and analyze all the data systematically.

Hammarskjold, E.; Ekholm, J.; Harms-Ringdahl, K. Reproducibility of work movements with carpenters' hand tools. *Ergonomics*. 1989; 32(8): 1005-18.
To find a model for testing possible new causes of accidents in the construction industry, the degree of precision with which carpenters habitually reproduced familiar work with ordinary hand-tools was investigated. Ten experienced carpenters performed standardized sawing, nailing and screwing tasks on two separate days, twice a day. The number of work movements and the time taken for each task were recorded. Perceived exertion was rated according to Borg's scale. The forces used while sawing and screwing were estimated and simulated on a dynamometer with appropriated handles. The activity of seven muscle groups of the work arm and shoulder was recorded with EMG and surface

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electrodes. Intra-individually the carpenters repeated the standardized work tasks with a high degree of precision (coefficients of variation less than 10%). In the dynamometer simulation, the precision was almost the same in screwing, but not in sawing. The perceived strain was consistently related to three different levels, with screwing rated 'hardest' and hammering 'easiest'. The EMG pattern varied among the ten subjects, but individual patterns and amplitudes were similar at the four trials. Parts of the model described can be used to test whether the reproducibility of movement performance changes after exposure to different work-related strains.

Hammarskjold, E.; Harms-Ringdahl, K. Effect of arm-shoulder fatigue on carpenters at work. *European Journal of Applied Physiology & Occupational Physiology*. 1992; 64(5): 402-09.

The purpose of the study was to analyse the effect of arm-shoulder fatigue on manual performance. Ten experienced carpenters performed three standardized tasks (nailing, sawing and screwing). Electromyographic activity was recorded from six arm-shoulder muscles and the performances were video-filmed. After 45 min of standardized arm-cranking (arm-shoulder-fatiguing exercise of approximately 70%-80% maximal oxygen consumption), the tasks were repeated. The number of work movements and the time taken for each task were recorded and the quality of the work performed was compared. After the fatiguing exercise, only nailing was perceived as being harder and more mistakes were made during nailing and sawing. Movement performance was not influenced during nailing but was slightly slower during sawing and faster during screwing. However, there were increased mean EMG amplitudes in the upper trapezius and biceps muscles during nailing, in the upper trapezius, anterior deltoid and infraspinatus muscles during sawing and in the anterior deltoid muscle during screwing. Of the muscles studied the upper trapezius and anterior deltoid muscles increased their activity most after the arm-shoulder-fatiguing exercise.

Hammarskjold, E.; Harms-Ringdahl, K.; Ekholm, J. Reproducibility of carpenters' work after cold exposure. *International Journal of Industrial Ergonomics*. 1992; 9(3): 195-204.

Note: NIOSH Abstract.

The intraindividual precision of performance of familiar tasks was examined immediately after exposure to cold. Ten healthy carpenters participated in this study. The subjects were exposed to moderate cold for 60 minutes, with additional cooling of the hand. Each subject then performed a series of standardized tasks at their own ordinary pace. The tools were kept at about 0 degrees-C. They were to hammer in ten nails upward with a carpenter's hammer, saw five pieces of pine with a hand saw, at eye level screw in five screws with a manual screwdriver, and then simulate the screwdriving on a dynamometer. Immediately after each task they rated the perceived exertion of the task according to a 15 grade scale for rating of perceived exertion. While the results indicated that the performance of the tasks was slower following exposure to cold, the quality of the work was not influenced. A few incidents occurred which indicated that accidents risks may increase under these conditions. Finger flexors, wrist extensors and shoulder elevators increased their activity and tasks could be rated as harder to perform. The results indicated that thoroughly learned movement patterns were rather stable in response to considerable cooling. Cooling of the hand was very individually perceived.

Hammarskjold, E.; Harms-Ringdahl, K.; Ekholm, J. Shoulder-arm muscular activity and reproducibility in carpenters' work. *Clinical Biomechanics*. 1990; 5: 81-87.

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The purpose of the present study was to analyse the levels of muscle activity that experienced carpenters reach in some arm-shoulder muscles when performing familiar tasks, and to find whether there are intra- and inter-individual similarities in muscle activity. Ten healthy carpenters performed twice on the same day: their tasks were, manual screwdriving at eye level, manual sawing on a saw horse, and nailing upward into the ceiling. Two weeks later the experiment was repeated. Normalized electromyography was used. The median activity levels during the period analysed did not exceed 15% of maximum electromyographic activity for any of the muscle groups studied. For some muscles and activities there were wide ranges of median activity levels. The most activated muscles in all three tasks were the trapezius pars descendens, infraspinatus and anterior deltoid. There was an intra-individual similarity between the median values from each trial. The prevalence of arm-shoulder-neck disorders has become nearly as great as that of low back disorders. Muscular overload has been discussed as one etiological factor. No studies have been found analysing the extent to which the ordinary working tasks of carpenters load their muscles or the degree of regularity in muscle activation.

Hammerskjold, E.; Harms-Ringdahl, K.; Ekholm, J.; Samuelson, B. Effect of short-time vibration exposure on work movements with carpenter's hand tools. *International Journal of Industrial Ergonomics*. 1991; 8(2): 125-34.

Note: NIOSH Abstract.

The effect of short term vibration exposure on work movements associated with carpenter's hand tools was examined. The study group consisted of ten healthy male carpenters, mean age 37 years. They had worked as carpenters for a mean of 18 years. They performed standardized nailing, sawing, and screwing tasks before and after being exposed to a 50 hertz 20 meters per square second vibration applied to the dominant hand for 10 minutes. Torques generated during the screwing task were measured. Electromyographic (EMG) activity was recorded from the muscles of the dominant arm and shoulder. Work movements during the tasks were video taped. Work quality was assessed by recording the number of nails that were bent or had to be replaced, how well the markings on the joists were followed during sawing, and how well the screws were screwed in. After vibration exposure the amplitude of the EMG signals were significantly decreased from the flexor digitorum and increased from the trapezius during nailing. EMG amplitudes were significantly increased from the flexor digitorum, extensor carpi, infraspinatus, and trapezius muscles during sawing. The amplitude of biceps activity during screwing was significantly decreased. The subjects rated the screwing task as the hardest, followed by the sawing and nailing tasks in that order. The level of perceived exertion was increased only for the nailing task after vibrational exposure; however, the relative rankings of the three tasks were not changed. Work quality was not significantly affected by vibration exposure. The mean number of pushes per subject during sawing was significantly decreased and the mean number of turns during the screwing task was significantly increased after vibration exposure. Vibration exposure did not significantly affect the mean torque exerted during the screwing task. No evidence of impaired coordination was seen. The authors conclude that the vibration exposure used does not significantly affect the performance of tasks using well known nonvibrating hand tools. No evidence of impaired coordination or changed movements that could increase the risk of accidents was observed.

Riihimaki, H.; Tola, S.; Videman, T.; Hanninen, K. Low-back pain and occupation. A cross-sectional questionnaire study of men in machine operating, dynamic physical work, and sedentary work. *Spine*. 1989; 14(2): 204-09.

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The frequency of sciatic pain, lumbago, and nonspecific low-back pain (LBP) and factors related to these symptoms were determined among men occupied in machine operating (541 longshoremen and 311 earthmover operators), dynamic physical work (696 carpenters), and sedentary work (674 municipal office workers). Sciatic pain was more common among machine operators and carpenters than among office workers, and also more frequent among machine operators than among carpenters. The occupational differences were considerably smaller with regard to lumbago and nonspecific LBP. In multivariate analysis, occupation, age, reported back accidents, and postural load showed significant independent effects on the occurrence of sciatic pain. Allowing for other risk indicators, the relative risk was 1.3 contrasting machine operators with both office workers and carpenters, but carpenters had no excess risk as compared with office workers.

Tola, S.; Riihimaki, H.; Videman, T.; Viikari-Juntura, E.; Hanninen, K. Neck and shoulder symptoms among men in machine operating, dynamic physical work and sedentary work. *Scandinavian Journal of Work, Environment & Health*. 1988; 14(5): 299-305.

Data on the occurrence of neck and shoulder symptoms and some qualities of work and leisure-time activities were gathered with a postal questionnaire sent to 1,174 machine operators, 1,045 carpenters, and 1,013 office workers. They were all men in the age range of 25-49 years. The response rate was 67-76%. The lifetime cumulative incidence of neck and shoulder symptoms was 81% for the machine operators, 73% for the carpenters, and 57% for the office workers. About half of the two groups of manual workers and 24% of the office workers had had symptoms during the last 7 d. Pain in the arms was indicated by 14-17% of the manual workers and 4% of the office workers. Symptoms during more than 30 d within the last 12 months were also more common among the manual workers than among the office workers. Within the manual worker groups, the machine operators had more symptoms than the carpenters. In a multivariate logistic regression analysis occupation, working in twisted or bent postures, age, draft, and job satisfaction proved to be significant risk indicators for neck and shoulder symptoms.

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Anonymous. NIOSH Alert, Request for Assistance in Preventing Knee Injuries and Disorders in Carpet Layers. NIOSH, Public Health Service, U.S. Department of Health and Human Services, DHHS (NIOSH) Publication No. 90-104. 1990: 7 pages.

Note: NIOSH Abstract.

In response to reports of bursitis of the knee, fluid buildup requiring knee aspiration, skin infections of the knee and a variety of knee symptoms reported by carpet layers, NIOSH issued the recommendations contained in this NIOSH Alert. Approximately 100,000 carpet layers were noted to be employed in the United States. Carpet layers make up less than 0.06% of the United States workforce, but they file 6.2% of all workers' compensation claims for traumatic knee injury, a rate that is 108 times that expected in the total workforce and the highest rate of any occupation reporting such claims. An evaluation of claims revealed that both the use of the knee kicker and kneeling were risk factors associated with a high frequency of knee disorders. Carpet layers were observed to spend the majority of their work time on their knees, but they seldom used

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protective knee pads. A safe alternative to the knee kicker was indicated to be the power stretcher, which helped eliminate impact trauma to the knee. Recommendations were provided and included the use of knee pads and the power stretcher, proper training of carpet layers, and conduction of further research to develop installation methods that further reduce the physical stress and knee trauma suffered by carpet layers.

Bhattacharya, A.; Mueller, M.; Putz-Anderson, V. Quantification of traumatogenic factors affecting the knees of carpet installers. *Applied Ergonomics*. 1985; 16(4): 243-50.

An ergonomics analysis of carpet installation tasks was performed. The purpose was to identify and quantify potential sources of biomechanical trauma that may be responsible for the high rates of knee morbidity found by previous researchers among carpet layers. Nine carpet layers were studied either at an apartment building worksite or at a training school. Results from a job analysis indicated that workers spent approximately 75% of their time in the kneeling position using a tool called a knee-kicker to stretch and install carpet. Awkward body postures were identified from films of workers installing carpets. At the moment of impact the knee is severely flexed, subtended angles were less than 60 degrees. To obtain measures of impact force on the knee, the kicker-tool was instrumented with a load cell. Workers who executed the hardest kicks with the tool produced impact peak forces that averaged 3019 newtons (N), which is equivalent to about four times body weight. Measures from an accelerometer attached to the worker's knee showed values in excess of 120 m/s², which are comparable to those found during vigorous running and jumping exercises. The results imply that repetitive impact of the knee joint from the use of the knee-kicker combined with knee flexion, kneeling and squatting may be responsible for the high level of occupational knee-morbidity found among carpet layers.

Bhattacharya, A.; Ramakrishanan, H.; Habes, D. Electromyographic patterns associated with a carpet installation task. *Ergonomics*. 1986; 29(9): 1073-84. Previous studies have indicated that the knee joint is subject to impact forces greater than 3000 newtons when workers use a knee-kicker to install carpet. Such forces may be modified, however, by the action of large muscle groups in the legs and upper body. To evaluate the role of these key muscle groups, electromyographic (EMG) data were collected from the rectus femoris, long head of the biceps femoris, anterior deltoid, and extensor carpi radialis muscles of eight male subjects. Each subject simulated the four static body postures most commonly used during carpet installation. These were (a) on hands and knees, (b) beginning kick cycle, (c) mid-kick cycle and (d) impact kick cycle. To assess the dynamic component of the task, each subject performed the act of carpet stretching using a knee-kicker. For both static and dynamic activities, the anterior deltoid showed the highest normalized EMG values. It was also found that immediately before the impact phase the knee flexor muscles contracted, and it appears that such muscle activity in conjunction with activities (not measured in this study) of other hamstring muscles, facilitates development of an optimal blow to the kicking tool. Finally, the results seemed to support the recommendation that forward body movement post-impact phase be minimized in order to reduce excessive activity of the shoulder flexors.

Ekstrom, H.; Engholm, I.; Nyqerst, B.; Wallenquist, A. The kneeling working posture -- a stepchild in ergonomic research. *Bygghalsan Bulletin*. 1981-07-01.

Note: English Abstract.

An abstract on solutions to the problem of the kneeling posture among carpet

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layers and sheet metal workers. The anatomy of the knee joint is poorly constructed for protracted strain in the kneeling position. The authors investigated the prevalence of knee symptoms in different trades in the Swedish building industry and found it to be closely related to the amount of work in the kneeling posture. After examining different materials used in knee protectors, the authors found much of the equipment available on the market for knee protection to be unsuitable due to inappropriate materials and faulty design. They then consider design solutions for a satisfactory knee protector.

Hallberg, U. Working with plastic carpets -- an ergonomic study. *Bygghalsan Bulletin*. 1981-07-01.

Note: English Abstract.

An abstract of a pilot study showing that back and knee disorders are common among carpetlayers. The results of this interview investigation also indicated that carpetlayers use few aids apart from their tools. Many of the carpetlayers said they would like to have aids which would reduce the strain on their backs and knees.

Kivimaki, J.; Riihimaki, H.; Hanninen, K.; Knee disorders in carpet and floorlayers and painters. *Scandinavian Journal of Work, Environment & Health*. 1992; 18(5): 310-06.

In an evaluation of the effect of kneeling work on the knees, 168 actively working carpet and floor layers and 146 house painters were examined with the aid of a questionnaire, a clinical examination, and radiography. Reported knee pain, knee accidents, and treatment regimens for the knees were more common among the carpet and floor layers than among the painters. Radiographic changes of the tibiofemoral joint were noted equally in the two occupational groups, but osteophytes of the patella were more common among the carpet and floor layers than among the painters. In a multivariate analysis, the determinants of osteophytosis of the knee were age, occupation, knee accidents, and smoking workers. This study indicates that kneeling work increases the risk of knee disorders and such radiographic changes that might be an initial sign of knee degeneration.

Kivimaki, J. Occupationally related ultrasonic findings in carpet and floor layers' knees. *Scandinavian Journal of Work, Environment & Health*. 1992; 18(6): 400-02.

Soft-tissue changes in the anterior aspect of the knees were evaluated with ultrasonography among 96 randomly selected carpet and floor layers and 72 painters. The ultrasonography showed thickening of the prepatellar or superficial infrapatellar bursa in 49% of the carpet and floor layers and 7% of the house painters. Fluid collection in the prepatellar or superficial infrapatellar bursa was noted for 10 carpet and floor layers, and this ultrasonographic finding was associated with knee pain in kneeling postures.

Liu, Y.; Huston, R.; Bhattacharya, A. Modelling of a carpet installer knee-kicker. *International Journal of Industrial Ergonomics*. 1988; 2(3): 179-82.

Note: NIOSH Abstract.

A method for modeling the mechanical properties of a carpet installer knee kicker was described. The knee kicker was used by the carpet installer to stretch a carpet and consisted of a rod with a viscoelastic knee pad on one end and a plate with barbs to catch and stretch the carpet on the other end. The plate is struck by the installer with the suprapatellar region of the knee. The corresponding model of a spring mass damper system was mathematically described and dynamically tested using a Hewlett Packard Structural Dynamics Analyzer. The stiffness of the knee kicker was dependent upon the compressive

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load. Typical kick motions were assessed using a four segment multilink system comprising the torso, the thigh, the lower leg, and the foot, and kicking force was evaluated using curve fitting and Laplace transformation techniques. The model was validated by high speed photography of a 148 pound subject using the knee kicker. The authors conclude that the typical knee kicker does not attenuate the impulse transmitted at the knee and suggest that the model can be used in the development of more highly protective knee kicker pads.

Tanaka, S.; Lee, S.; Halperin, W.; Thun, M.; Smith, A. Reducing knee morbidity among carpetlayers. *American Journal of Public Health*. 1989; 79(3): 334-5.

Carpetlayers have a high prevalence of occupational knee morbidity, partly attributable to their use of the knee kicker to stretch carpet for wall-to-wall installation. While a mechanical alternative "power stretcher" is available, knee kickers are still widely used. A questionnaire survey indicated that unavailability of the mechanical stretcher at installation sites was a major factor for continued use of the knee kicker. Strategies to reduce use of the knee kicker are discussed.

Tanaka, S.; Smith, A.; Halperin, W.; Jensen, R. Carpet-layer's knee [letter]. *New England Journal of Medicine*. 1982; 307(20): 1276-7.

Thun, M.; Tanaka, S. Health Hazard Evaluation Report No. HETA-82-065-1664, Carpet and Floorlayers. Hazard Evaluations and Technical Assistance Branch, NIOSH, U.S. Department of Health and Human Services, Cincinnati, Ohio. 1986: 30 pages.

Note: NIOSH Abstract.

The occurrence of knee disease among carpetlayers was examined in three ways: Workers' Compensation claims were reviewed; the ergonomic forces transmitted to the knee during use of a knee kicker (carpet stretching tool) were determined; and a medical study of knee disease in construction workers was conducted. The evaluation was requested by Local 873, Cincinnati, Ohio, of the Resilient Floor Layers and Decorator's Union, because of the frequency of knee injuries resulting in accumulation of fluid and damage to cartilage. The local represents approximately 170 members. Carpetlayers and floorlayers submitted a disproportionately large fraction of claims for knee joint inflammation attributed to kneeling, leaning, repetition of pressure or striking against a stationary object. The ergonomic study determined that using a knee kicker may generate a force of up to 3200 newtons, transmitted directly to the suprapatellar area. A questionnaire study indicated that carpetlayers and floorlayers reported an increased frequency of bursitis, needle aspiration of knee fluid, skin infections of the knee, and other knee symptoms compared to millwrights and bricklayers. Tile, terazzo and marble setters reported similar problems. Chronic kneeling and the use of the knee kicker are considered to be associated with occupational knee trauma. The authors recommend that workers wear knee pads and use a power stretcher rather than a knee kicker when possible. It is also recommended that further research be conducted to develop a carpet stretching device that will be mobile and efficient and yet will reduce ergonomic trauma to the knee.

Thun, M.; Tanaka, S.; Smith, A.; Halperin, W.; Lee, S.; Luggen, M.; Hess, E. Morbidity from repetitive knee trauma in carpet and floor layers. *British Journal of Industrial Medicine*. 1987; 44(9): 611-20.

Carpet layers comprise less than 0.06% of the United States workforce yet they submit 6.2% of compensation claims for traumatic knee inflammation. Their work involves multiple sources of acute and chronic knee trauma including kneeling, pressure from sharp objects, and use of a device called a "knee kicker" to stretch

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wall to wall carpet. To characterise the knee morbidity in carpet layers and to identify occupational risk factors, a questionnaire was completed by 112 carpet and floor layers, 42 tile and terrazzo setters, and 243 millwrights and bricklayers (MWBL). The MWBL comparison workers seldom kneel and do not use a knee kicker. Physical and x-ray examinations were conducted on a subset of 108 respondents to validate the questionnaire responses. Compared with the MWBL, carpet layers reported more frequent bursitis (20% v 6%), needle aspiration of knee fluid (32% v 6%), and skin infections of the knee (7% v 2%). A score indicating frequency of using the knee kicker was the only statistically significant predictor of bursitis, whereas the score for kneeling was one of several predictors of knee aspiration and skin infections of the knee. These data suggest that carpet and floor layers experience substantially more knee morbidity than other occupational groups, and that kneeling and use of the knee kicker are risk factors providing opportunities for prevention.

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Adlington, R.; Barbier, J.; Koningsveld, E.; Lehtinen, P.; Lindblad, A.; Meesman, O. Survey of working environment in concrete construction. *Bygghalsan Bulletin*. 1983-05-01.

Note: English Abstract.

An abstract of a study of the safety and health hazards encountered by concrete workers, identifying several ergonomic hazards, such as the lifting and carrying of reinforcement bars and uncomfortable working postures, particularly bending forward.

Burdorf, A.; Govaert, G.; Elders, L. Postural load and back pain of workers in the manufacturing of prefabricated concrete elements. *Ergonomics*. 1991; 34(7): 909-18.

In a population of male workers in a concrete manufacturing plant (n = 114), the occurrence of back pain was studied in relation to a control group of maintenance engineers (n = 52). The prevalence of back pain in the 12 months preceding the investigation was 59% among the concrete workers, and 31% among the controls. After excluding persons with existing back pain before starting work in the present factory, a comparison between concrete workers and maintenance engineers showed an aged-adjusted odds ratio for back pain of 2.80 (1.31-6.01). Postural load of workers in both plants were measured using the Ovako Working Posture Analysis System. During 4009 observations working postures concerning the back, lower limbs, and lifting activities were recorded. The average time spent working with a bent and/or twisted position of the back was found to contribute to the prevalence of back pain. The results of this study also suggest that exposure to whole-body vibration, due to operating vibrotables, is a second risk factor for back pain.

Lindstrom, K.; Wickstrom, G.; Riihimaki, H.; Nummi, J.; Wiikeri, M.; Saari, J.; Launis, M. Reinforced Concrete Workers. Part 1. Working Conditions and State of Health - A Questionnaire; Part 2. Clinical Examination; Part 3. Ergonomic Analysis. Institute of Occupational Health, Helsinki, Finland, 3 Booklets, 81 pages, 134 pages, 141 pages. 1974.

Note: NIOSH Abstract.

In the first of these 3 booklets, results of an inquiry among 298 reinforced concrete workers on their working experience and opinions on their work and

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health are reported. Almost all found the work physically heavy, and a majority found it mentally demanding. The main problems were working position, lifting, cold and draughts. Booklet 2 reports the clinical findings in these men. The chief effects of the work were: degenerative changes and loss of curvature of cervical spine; muscle tension in shoulder; neck and shoulder pain; tenderness of elbow; low back pain. In booklet 3, the relative time spent in different positions was studied and the results tabulated, with some consideration of heart rate. The standing and bending positions dominated in all work phases. The physical load of preparations (taking the steel from the stacks, pulling it to the cutter, and cutting it) was greater than that of reinforcement work. The factors causing the greatest strain on the back were: long periods of work in a bent position and the need for sudden effort. Technical improvements are proposed on the basis of 7 typical construction sites. (Finnish).

Niskanen, T. Accidents and minor accidents of the musculoskeletal system in heavy (concrete reinforcement work) and light (painting) construction work. *Journal of Occupational Accidents*. 1985; 7: 17-32.

The aim of this study was to clarify the differences between concrete reinforcement workers and painters in the frequency, causes, and types of accidents and minor accidents affecting the musculoskeletal system. Accident report forms sent by construction firms to insurance companies were analyzed in detail. Accidents led to at least a 3-day absence from work. The incidence rate (accidents x 1,000/number of workers) of accidents affecting the musculoskeletal system was four times as high among the reinforcement workers (124) than among the painters (30). Minor accidents affecting the musculoskeletal system were reported five times more frequently by the reinforcement workers (1.9 minor accidents/1,000 workhours) than by the painters (0.4 minor accidents/1,000 workhours). Altogether 440 man months of reinforcement workers and 429 man months of painters were covered. The accidents and minor accidents were classified according to the following categories: work phase; work posture/ work movement at moment of occurrence; ultimate event of occurrence; the part of body injured; and the injury.

Nummi, J.; Jarvinen, T.; Stambej, U.; Wickstrom, G. Diminished dynamic performance capacity of back and abdominal muscles in concrete reinforcement workers. *Scandinavian Journal of Work, Environment & Health*. 1978; 4(Suppl 1): 39-46. The dynamic performance capacity of back and straight abdominal muscles was clinically examined in 295 male Finnish concrete reinforcement workers aged 19 to 64 years and engaged in heavy physical work including prolonged stooping. In 24% of the men both back and straight abdominal muscle performance capacity was reduced, in 18% only the capacity of the straight abdominal muscles, and in 4% only the performance of the back muscle. The prevalence of diminished trunk muscle performance capacity increased rapidly with age. Diminished back muscle performance capacity was associated with a history of sciatica ($\chi^2 = 16.9$, $p < 0.001$) and diminished performance capacity of the straight abdominal muscles with a history of lumbago ($\chi^2 = 5.9$, $p < 0.02$) after adjustment for age. Diminished back muscle performance was associated with backache ($\chi^2 = 16.9$, $p < 0.001$) and sharp pain in the back ($\chi^2 = 4.5$, $p < 0.05$) during an ordinary workday, as was also diminished performance of the straight abdominal muscles ($\chi^2 = 23.8$, $p < 0.001$ and $\chi^2 = 7.3$, $p < 0.01$, respectively). No association between length of exposure to the back loads in reinforcement work and the prevalence of diminished trunk muscle performance capacity could be established.

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Riihimaki, H. Back pain and heavy physical work: a comparative study of concrete reinforcement workers and maintenance house painters. *British Journal of Industrial Medicine*. 1985; 42(4): 226-32.

In an investigation of the effect of heavy physical work on the back, 217 concrete reinforcement workers aged 25-54 and a reference group of 202 house painters of similar age were interviewed about their back symptoms. Data on occupational history, accidents, and leisure time activities were collected with a questionnaire. The cumulative incidence rate of sciatic pain was significantly higher among the reinforcement workers than the painters. As regards the occurrence of lumbago and non-specific back pain, however, the groups were alike. In both occupational groups sciatic pain during the previous 12 months was associated with earlier back accidents (odds ratio 2.8, 95% confidence interval 1.8-4.5). The accident rate of the reinforcement workers was higher than that of the painters, and this difference seemed to explain their higher rate of sciatic pain.

Riihimaki, H.; Mattsson, T.; Zitting, A.; Wickstrom, G.; Hanninen, K.; Waris, P.

Radiographically detectable degenerative changes of the lumbar spine among concrete reinforcement workers and house painters. *Spine*. 1990; 15(2): 114-19. In this study of lumbar degeneration and the role of mechanical loading in its development, lateral lumbar radiographs of 216 concrete reinforcement workers and 201 house painters aged 25-54 years were examined. Disc space narrowing occurred at about 10 years and spondylophytes at about 5 years younger age in the former than in the latter group. Risk ratios (RR) were estimated from the regression coefficients of logistic regression models. RR for the univariate effect of occupation on disc space narrowing was 1.8, and adjustment for age, earlier back accidents, height, body mass index and smoking had only a minor effect on this relationship, adjusted RR 1.8. The crude RR for spondylophytes was 1.5, and the adjusted RR 1.6. Earlier back accidents showed a significant univariate relationship with DSN, but in multivariate analysis this variate did not retain its significance. It was concluded that heavy physical work enhances the degenerative process of the lumbar spine. Materials handling and postural loading are proposed to be occupational factors of importance in the development of both disc space narrowing and spondylophytes.

Riihimaki, H.; Wickstrom, G.; Hanninen, K.; Luopajarvi, T. Predictors of sciatic pain among concrete reinforcement workers and house painters--a five-year follow-up. *Scandinavian Journal of Work, Environment & Health*. 1989; 15(6): 415-23.

In a study of the association of occupation and several other determinants with the occurrence of sciatic pain, 167 concrete reinforcement workers and 161 house painters were followed for five years. Base-line data were obtained with a questionnaire, an interview on back symptoms, a clinical examination, and a radiograph of the lumbar spine. Follow-up data on back symptoms were obtained with a postal questionnaire. Concrete reinforcement work was associated with an increase in the risk of sciatic pain, in both a cross-sectional and a prospective study. Reported back accidents contributed to the risk of sciatic pain. Previous history of back symptoms was the most powerful predictor of sciatic pain prospectively. Degenerative changes were related to sciatic pain in retrospect, but prospectively this relationship was weaker. Body height and history of stress episodes showed some association with sciatic pain; abdominal muscle strength, body mass index, and smoking did not; and back muscle strength was associated only retrospectively.

Riihimaki, H.; Wickstrom, G.; Hanninen, K.; Mattsson, T.; Waris, P.; Zitting, A.

Radiographically detectable lumbar degenerative changes as risk indicators of

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back pain. A cross-sectional epidemiologic study of concrete reinforcement workers and house painters. *Scandinavian Journal of Work, Environment & Health*. 1989; 15(4): 280-85.

The association between radiographically detectable degenerative changes in the lumbar spine and back symptoms was studied, along with the possible effect of occupational work load. The subjects were 216 concrete reinforcement workers and 201 house painters. A questionnaire provided information on work history and earlier back accidents, and a standardized interview produced data on back symptoms. The occurrence of disc space narrowing, anterior and posterior spondylophytes, and end-plate sclerosis was recorded separately for each intervertebral space from lateral lumbar radiographs. Moderate to severe degenerative changes were associated with increased risk of sciatic pain but not with the occurrence of lumbago or nonspecific back pain. The different types of degenerative changes provided no further information. In a multivariate logistic regression analysis degenerative changes and earlier back accidents were significant independent predictors of sciatic pain. When these two variates were allowed for, the effect of occupation was not significant.

Saari, J.; Wickstrom, G. Load on back in concrete reinforcement work. *Scandinavian Journal of Work, Environment & Health*. 1978; 4(Suppl 1): 13-19.

The demands of work on the back of concrete reinforcement workers were determined through 4,327 observations of the various work postures and the weights lifted. Static loads from forward-leaning and bent-double postures were found to be common. In the preparation of intermediate and thick rods, forward-leaning was required for more than a third of the total work time, while one central assembly task required work in the bent-double posture for 58% of the total work time. The dynamic loads were of less importance, even though weights over 30 kg were lifted about 15% of the time in the preparation tasks and momentary forces approaching 1,000 N were occasionally needed. The bent-double posture, combined with or quickly followed by additional strain from, for example, weight lifting or slipping, was considered the most probable cause for possible signs of accelerated lumbar disc degeneration, while also the forward-leaning postures could be responsible for reversible low-back symptoms.

Schneider, S. Observations on ergonomic hazards at the IAM worksite. (Unpublished Paper, 1991). 3 pages.

Observations on the hazards encountered in the course of iron work, concrete work, and masonry work. Includes solutions and suggestions for ergonomic improvements.

Wickstrom, G. Symptoms and signs of degenerative back disease in concrete reinforcement workers. *Scandinavian Journal of Work, Environment & Health*. 1978; 4(Suppl 1): 54-8.

Concrete reinforcement work causes great static loads on the back from the prolonged adoption of bent-double work postures during the tying of steel rods and from substantial dynamic loads during the lifting and pulling of rods from the stack. Subjective manifestations and objective signs of "degenerative back disease" are common in active reinforcement workers. An age- and sex- adjusted comparison of the findings was, however, possible only with one other occupational group, computer technicians, who also often work in awkward positions. A history of sciatica and pain during forward bending in a clinical examination were significantly more common in reinforcement workers than in computer technicians. This finding suggests an effect of reinforcement work on the back, but definite conclusions require further study.

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Wickstrom, G.; Hanninen, K. Determination of sciatica in epidemiologic research. *Spine*. 1987; 12(7): 692-98.

The international classification of diseases is unsuitable for epidemiologic research on the etiology of degenerative back disease. In cross-sectional studies of occupationally active populations, the occurrence of various symptoms and signs of back disease may be established. However, recommendations as to what data to gather or how to combine it into meaningful entities are not yet established. To validate reported sciatic pain by clinical findings, 252 reinforcement workers and 231 painters, all men, 20-64 years of age, were examined by nine tests. In the reinforcement workers exposed to heavy occupational loads the reports of sciatica during the previous month were clearly related to several clinical findings. The tests for restriction and pain on bending forward and sideward gave sensitivity values of 0.36-0.61 and specificity values of 0.82-0.87. Combining the results of the separate tests into pairs enhanced the sensitivity to 0.62-0.68, but reduced the specificity to 0.77-0.78. Referring to the current results, recommendations include a structured inquiry into sciatic pain during the previous month, backed up by clinical tests for range of and pain on lumbar movement, when studying the occurrence of back syndromes in physically heavy trades.

Wickstrom, G.; Hanninen, K.; Mattsson, T.; Niskanen, T.; Riihimaki, H.; Waris, P.; Zitting, A. Knee degeneration in concrete reinforcement workers. *British Journal of Industrial Medicine*. 1983; 40(2): 216-19.

The loads on the knees in concrete reinforcement work and maintenance painting were analysed on eight construction work sites. A total of 352 reinforcement workers and 231 painters. Finnish men aged 20-64, were clinically and radiologically examined to determine the condition of the knee joints in active workers. The loads on the knees and the occurrence of minor injuries and accidents were higher in reinforcement work than in painting, but the occurrence of symptoms, clinical signs, and radiological findings was equally common in both groups. Reinforcement work seemed to provoke more symptoms from degenerated knees than painting.

Wickstrom, G.; Hanninen, K.; Lehtinen, M.; Riihimaki, H. Previous back syndromes and present back symptoms in concrete reinforcement workers. *Scandinavian Journal of Work, Environment & Health*. 1978; 4(Suppl 1): 20-28.

Two hundred and ninety-five male Finnish concrete reinforcement workers, aged 19-64 years and engaged in heavy physical work including prolonged stooping, were clinically examined in a cross-sectional study. A history of sciatica was reported by 42% of the men, and a history of lumbago by 33%. The prevalence of the reported experience of sciatica and lumbago doubled in the two decades from age 25-34 onward. Half of those with a history of sciatica had also experienced lumbago; two-thirds of those who reported a history of lumbago had also suffered from sciatica. Back symptoms during an ordinary workday were reported as follows: ache 51%, fatigue 47%, stiffness 41% and sharp pain 13%. The correlation between the four symptoms was slight. Ache ($\chi^2 = 23.5$, $p < 0.001$) and stiffness ($\chi^2 = 12.0$, $p < 0.001$) were more common in workers with a history of sciatica than in workers without a history of lumbago or sciatica. In the analysis of the results for a possible effect of reinforcement work on back morbidity, the occurrence of back symptoms and syndromes was not found to be associated with length of reinforcement work, while comparison of a history of low-back pain syndromes between reinforcement workers and computer technicians showed experience of sciatica to be somewhat more common in the

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reinforcement workers ($\chi^2 = 5.2$, $p < 0.05$).

Wickstrom, G.; Niskanen, T.; Riihimaki, H. Strain on the back in concrete reinforcement work. *British Journal of Industrial Medicine*. 1985; 42(4): 233-39.

To investigate the long term effect of heavy construction work on the back the occurrence of postures, lifting, carrying, and accidents in concrete reinforcement work and in maintenance house painting were measured. The 32,620 observations covering 272 work hours showed that reinforcement work necessitated stooped postures and heavy lifting more often than did painting. Reported minor back accidents were more than ten times as common in reinforcement work than in painting (1.3 compared with 0.11 accidents per man-year, p less than 0.001). Accidents of the musculoskeletal system, registered by the insurance companies, were also several times more common in reinforcement work (81 compared with 25 per 1000 man-years, p less than 0.001). The premature development of lumbar degeneration detected in the clinical study of the reinforcement workers was evidently due to the occupational strain on the back. The different types of hazardous back loads probably potentiate the effects of each other.

Wickstrom, G.; Nummi, J.; Nurminen, M. Restriction and pain during forward bending in concrete reinforcement workers. *Scandinavian Journal of Work, Environment & Health*. 1978; 4(Suppl 1): 29-38.

Two hundred and ninety-five male Finnish concrete reinforcement workers, aged 19-54 years and engaged in heavy physical work including prolonged stooping, were clinically examined in a cross-sectional study. Restriction of lumbar flexion was found in 38% of the men, and pain during forward bending in 19%. Restriction of lumbar flexion was strongly related to age, while pain during forward bending showed a weaker association. A history of sciatica was more common in the men with restriction during forward bending ($\chi^2 = 6.0$, $p < 0.05$) and in the men with pain during forward bending ($\chi^2 = 17.2$, $p < 0.001$) than in the men without. Restricted lumbar flexion was related to diminished back muscle performance capacity ($\chi^2 = 28.0$, $p < 0.001$). Pain during forward bending was also related to diminished back muscle ($\chi^2 = 25.3$, $p < 0.001$) and straight abdominal muscle ($\chi^2 = 21.2$, $p < 0.001$) performance capacity. The prevalence of radiologically detectable lumbar disc degeneration was associated with restricted lumbar flexion ($\chi^2 = 20.2$, $p < 0.001$). Comparison of the occurrence of restricted lumbar flexion and pain during forward bending to length of reinforcement work experience showed no relation after adjustment for age. When reinforcement workers were compared to computer technicians, restricted lumbar flexion was equally common in both groups, while the occurrence of pain during forward bending was more common among reinforcement workers ($\chi^2 = 8.6$, $p < 0.01$).

Wiikeri, M.; Nummi, J.; Riihimaki, H.; Wickstrom, G. Radiologically detectable lumbar disc degeneration in concrete reinforcement workers. *Scandinavian Journal of Work, Environment & Health*. 1978; 4(Suppl 1): 47-53.

Two hundred and ninety-five male Finnish concrete reinforcement workers, aged 19 to 64 years and engaged in heavy physical work including prolonged stooping, were radiologically examined by antero-posterior and lateral views of the lumbar spine while they were standing. The findings of lumbar disc degeneration were classified as none, slight, moderate or severe. The prevalence and degree of radiologically detectable lumbar disc degeneration depended strongly on age and increased especially rapidly from 40 to 44 years on. Lumbar disc degeneration showed an age-independent association to both a history of lumbago ($\chi^2 =$

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10.5, p less than 0.01) and a history of sciatica ($\chi^2 = 11.8$, p less than 0.001). When disc degeneration was compared to reports of stiffness, fatigue, ache, and sharp pain in the back during an ordinary workday, no statistically significant associations were found, while disc degeneration was found to be slightly more common ($\chi^2 = 4.6$, p less than 0.05) in the men reporting back symptoms as they bent down than in the men who did not report such symptoms. No association between length of exposure to static and dynamic back loads in reinforcement work and the prevalence of lumbar disc degeneration could be established, but definite conclusions on the possible effect of reinforcement work on the lumbar spine could not be drawn from the data.

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Draaisma, D.; Grundemann, R.; Hoolboom, H. Job, health and well-being of foremen in the building industry. C. Hogstedt; C. Reuterwall (Eds.). Progress in Occupational Epidemiology: Proceedings of the Sixth International Symposium on Epidemiology in Occupational Health, Stockholm, Sweden, 16-19 August 1988. Amsterdam: Elsevier Science Publishers B.V.; 1988: 307-10.

This two-part study examines whether foremen can be considered to be at high risk of leaving their trade because of musculoskeletal complaints and diseases, and whether there are health effects of working under very high time pressure. The results can be interpreted in terms of the "relative healthy worker effect" as a result of two different effects among building foremen compared with other middle managers. The following process is hypothesized. Building foremen have a greater workload. This does not lead to significantly more health effects in the younger age group (34 and under). In the middle age group (35-49 years), however, health effects become more apparent, followed by more drop-out of building foremen. As a result the middle age category of foremen is healthier on the average. In the older age category, because of the persisting greater workload of the foremen, differences in health diminish, so that foremen no longer have better health. Only preliminary results of the second part of the study were available, but it was clear that health influences the process of staying and dropping out. Parts of the healthy worker effect among the building foremen appear to exist.

Stenlund, B.; Goldie, I.; Hagberg, M.; Hogstedt, C.; Marions, O. Radiographic osteoarthritis in the acromioclavicular joint resulting from manual work or exposure to vibration. *British Journal of Industrial Medicine*. 1992; 49(8): 588-93. The hypothesis that manual work and exposure to vibration are antecedents to the development of osteoarthritis was assessed employing a cross sectional study design. The frequency of osteoarthritis in the acromioclavicular joint was studied in three groups of workers in the construction industry. Two groups were manual workers (54 bricklayers and 55 rock blasters); the third group consisted of 98 foremen. The radiographic appearance of the right and left acromioclavicular joints was classified into one of five grades of osteoarthritis. A protocol was developed to assess exposure on the basis of job title, years of manual work, total weight lifted during working life, and total hours of exposure to vibrating tools. Odds ratios for job titles (manual worker v foreman) and for years of manual work as indicators of exposure were of similar magnitude of around 2.5. Construction workers who had lifted more than 709 tonnes had an increased risk of developing severe osteoarthritis of the right acromioclavicular joint, odds ratio: 2.62 (95% confidence interval (95% CI), 1.13-6.06). The odds ratio for the

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left side was 7.67 (95% CI, 2.76-21.34). In the analysis of vibration exposure, workers who had been highly exposed to vibration had an odds ratio of 1.99 (95% CI, 1.00-3.92) on the right side and 2.20 (95% CI, 1.07-4.56) on the left. This effect almost disappeared after simultaneous adjustment for manual work. Occupational and ergonomic factors, such as the sum of lifted tonnes during working life, job title, and the sum of years of manual work seem to be risk factors for osteoarthritis of the acromioclavicular joint, whereas vibration alone was a weaker risk factor.

Stenlund, B.; Goldie, I.; Hagberg, M.; Hogstedt, C. Shoulder tendinitis and its relation to heavy manual work and exposure to vibration. *Scandinavian Journal of Work Environment & Health*. 1993; 19: 43-49.

Three categories of construction industry workers (54 bricklayers, 55 rockblasters, and 98 foremen) were compared in a cross-sectional study. In a structured interview they reported exposure to loads lifted, vibration, and years of manual work. They were also subjected to a clinical investigation including medical history and a detailed shoulder examination. Among the rockblasters 33% had signs of tendinitis in the left and 40% in the right shoulder. Among the bricklayers and foremen 8-17% had signs of shoulder tendinitis. In a multiple logistic regression being a rockblaster compared with being a foreman showed an odds ratio (OR) of 3.33 for left-sided and 1.71 for right-sided shoulder tendinitis. Vibration exposure yielded an OR of 1.84 and 1.66 for the left and right sides, respectively. Vibration exposure or work as a rockblaster seemed to be risk indicators for tendinitis of the shoulders.

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Anonymous. Protect your knees. *Bygghalsans Broschyr*. 1983; 10(1): 9 pages.

Note: NIOSH Abstract.

Knee pain and protection are reviewed. An unprotected knee resting against a hard surface is not capable of supporting the weight of the body for any extended period of time. The contact surface is very small and the force per unit surface area becomes very large resulting in injuries to the cartilage in the knee joint. The incidences of knee pain among selected occupational groups are: floor layers, 26 percent; sheet metal workers, 17 percent; refrigeration installers, 16 percent; pipe fitters, 15 percent; electricians, 14 percent; roofers, masons, and carpenters, 13 percent; painters and concrete workers, 12.5 percent; crane operators, machine operators, stone workers, and scaffold builders, 12 percent; glass workers and insulation installers, 11 percent; foremen and drivers, 10 percent; and clerks, 5 percent. Other causes of knee pain include aging and injuries due to sports activities. Knee protection is summarized. Anyone who works in a kneeling position should use knee pads. The pads help distribute the body weight over a larger surface area, reducing the risk of knee pain. (Swedish).

Astrand, I. Degree of strain during building work as related to individual aerobic work capacity. *Ergonomics*. 1967; 10(3): 293- 303.

This study establishes a definite relationship between aerobic work capacity as measured in the laboratory and the occupational work-load level spontaneously chosen by the individual. This level corresponds to about 40 per cent of the individual maximal capacity. Persons with a large capacity are probably more productive than those with a small capacity.

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Bye, A. Musculoskeletal disorders among employees in building and construction industry. [Norwegian]. Tidsskrift For Den Norske Laegeforening. 1991; 111(3): 337-40.

A questionnaire was distributed to 2,696 employees in the construction industry in order to determine the prevalence of subjectively experienced musculoskeletal strain in four regions of the body. A total of 40.3% of the employees had pain at the time of questioning. The percentage of the employees with complaints increases gradually with age, but least for backache. A comparison of different age groups of employees in two occupations reveals that carpenters in the age group 30-40 years have more than ten times as many musculoskeletal disorders in their arms and hands as office workers in the same age group. We presume that more than 90% of these disorders are caused by factors in the working environment. The author concludes that it is important to continuously collect information on musculoskeletal disorders among workers, and analyze all the data systematically.

Cook, T.; Zimmermann, C. A symptom and job factor survey of unionized construction workers. S. Kumar. Advances in Industrial Ergonomics and Safety IV. London: Taylor & Francis; 1992: 201-6.

A two-part survey was completed by 526 unionized construction workers in eastern Iowa. The survey consisted of a job factors analysis and symptom survey. The low back, neck, wrist/hand, knee and ankle/foot were the predominant symptomatic areas. Job factors perceived most problematic included prolonged positions, awkward postures, uncomfortable conditions, very hard work and reaching overhead. Examination of relationships between selected symptom areas resulting in missed work and perceived problems with job factors revealed several significant odds ratios.

Culver, C.; Marshall, M.; Connolly, C. Analysis of construction accidents: the Workers' Compensation Database. Professional Safety. 1993; 38(3): 22-27.

This article presents the analysis of workers' compensation claims for 359,765 construction accidents occurring in 10 states for the period 1985 to 1988. Data were obtained from the Supplementary Data System established by the Bureau of Labor Statistics. The analysis considered the variation of the number of accidents and accident rate (accidents per a given number of employees exposed) during the four-year period and the influence of factors such as geography, industry group, construction trade, worker age, etc., on accident statistics. [Strains and sprains represented the most frequently occurring type of injury, accounting for 36 percent of the total. The back was the most frequently affected body part, being involved in 21 percent of accidents. Causes of accidents experienced by various construction trades were analyzed. Clearly, accident causes varied by trade. Frequency of overexertion occurrence was similar, ranging between 21 percent and 28 percent, with the across-trade average being 24 percent.] This article presents selected results of a large study; complete results are available in an OSHA report: Construction Accidents: The Workers' Compensation Database 1985-1988.

Damlund, M.; Goth, S.; Hasle, P.; Jeune, B.; Munk, K. The incidence of disability pensions and mortality among semi-skilled construction workers in Copenhagen. A retrospective cohort study with two control groups. Scandinavian Journal of Social Medicine. 1982; 10(2): 43-47.

The aim of the present study was to discover whether the incidence of disability pensions and mortality was higher amongst semi-skilled construction workers (SCW) in Copenhagen than in two control groups from the same geographic

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area. The population investigated consisted of a fixed cohort of 3537 SCW from Copenhagen as per 1/5/1975. The two control groups comprised 3818 Copenhagen members of the Warehouse Workers' union and a group of Copenhagen members of the Semi-skilled Worker's Union age-matched to the SCW cohort, both as per 1/5/75. Up to 31/12/79, a total of 102 SCW were granted disability pensions, compared with 89 and 77 in the two control groups respectively, i.e. a significantly higher frequency of award of disability pension among SCW than among warehouse workers (p less than 0.05). This was due especially to a higher frequency of disability pensions granted because of musculoskeletal diseases and cancer in SCW. The number of deaths was recorded from 1/5/75 to 30/11/78. No differences in overall mortality were found among the three groups, although slightly fewer deaths from lung cancer and ischaemic heart diseases and more suicides were observed among the construction workers. Selection bias and the effect of the working environment are discussed against the background of a concurrent investigation of the state of health and working conditions of SCW.

- Damlund, M.; Goth, S.; Hasle, P.; Munk, K. Low back strain in Danish semi-skilled construction work. *Applied Ergonomics*. 1986; 17: 31-39.
Danish semi-skilled construction workers (SC-workers) perform a variety of tasks in building construction, civil engineering and rebuilding. A previous epidemiologic study indicated a high occurrence of low back pain (LBP) among these workers. The study was designed to quantify the major occupational risk factors associated with the development of LBP, i.e., inclined postures, repetitive movements, heavy lifts, pushing/pulling motions, sudden unexpected strains and whole body vibrations in this group of construction workers. First, a study of occupational activity of 112 SC-workers on eight construction sites during two separate five-day periods was carried out. This was followed by an observational study of the nine work tasks most common to SC-workers. Heavy lifts, pushing/pulling motions and sudden unexpected strain occurred most frequently in the work, while inclined postures, repetitive movements and whole body vibrations characterized different parts of the work. Assessments of the strain were made on the basis of techniques given in the literature.
- Damlund, M.; Goth, S.; Hasle, P.; Munk, K. Low-back pain and early retirement among Danish semiskilled construction workers. *Scandinavian Journal of Work, Environment & Health*. 1982; 8(Suppl 1): 100-04.
According to new regulations Danish trade union members are able to retire earlier than normal, at the age of 60-65. One of the reasons for retirement might be symptoms of wear and tear, eg, low-back pain. Questionnaires were sent to 157 semiskilled construction workers and 210 members of a reference group. Forty percent of the construction workers reported low-back pain as one of the reasons for retirement, whereas the corresponding percentage of referents was 25. Low-back pain occurred in the year before retirement for 68% of the construction workers and 50% of the reference group. The relationship between low-back pain, selection, and semiskilled construction work is discussed.
- Eastern Iowa Construction Alliance/University of Iowa. Joint Project on Reduction of Work-Related Injuries and Illnesses Through Ergonomic Intervention. Final Report, Phase I. (Unpublished, 1991).
Preliminary research that found trade specific patterns of both symptoms and job factors in construction work.
- Gonner, H. Noise and vibration reduction on construction machinery. *Ergonomics in*

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Developing Countries: An International Symposium; 1985; Jakarta, Indonesia. Geneva: International Labor Office; 1987; Occupational Safety & Health Series No. 58: 224-37.

Note: NIOSH Abstract.

A mobile test facility for analyzing the effectiveness of noise and vibration suppression devices on construction equipment was described. The facility was developed by the Tiefbau Berufsgenossenschaft (The Insurance Association for Occupational Safety and Health in Civil Engineering) (TBG), Munich, Federal Republic of Germany. The facility consisted of high grade instruments for recording noise and vibrations. The data were analyzed by a weighting network that was based on a digital 0.33 octave analyzer. The data were processed on a personal computer and the weighted results were displayed on a video display terminal. The system contained a backup diskette memory that stored the programs and data. The noise level recorder was linked to the analogue output of the octave analyzer. This feature made it possible to provide hard copy of the noise levels as a function of time and their frequency spectra. Examples of analyses performed by the TBG facility were provided. These included analyses of the effects of noise suppression techniques on a wheeled loader, a vibrating roller, a joint cutter, and an analysis of a method for reducing vibrations on a wheeled loader.

Helander, M. Ed.). Human Factors/Ergonomics for Building and Construction. New York: John Wiley & Sons; 1981.

The objective of this book is to present information from the social sciences, particularly human factors and ergonomics, and apply it to construction work. The book is primarily written for civil engineers, managers, and safety personnel in the building/ construction industry. Much of the information presented is very general in nature.

Helander, M. Safety hazards and motivation for safe work in the construction industry. International Journal of Industrial Ergonomics. 1991; 8(3): 205-23.

Note: NIOSH Abstract.

A discussion was presented to summarize what has been done in construction safety and ergonomics as it relates to the safety of the workers. A general overview of the safety problem in this industry was provided including tasks and procedures, types of jobs, and the use of various tools and machines. A review was presented dealing with safety and ergonomic design of procedures, tools and machines. Research on hazard perception, motivation for safe performance, and the effect of attitudes on safe behavior was summarized. Specific data was presented concerning trends in construction safety; construction fatalities in the United Kingdom; analysis of Swedish construction accidents; main hazards and main safety aspect of the supervisor, carpet installer, sheet metal worker, plumber, electrician, carpenter, painter, mason, operating engineer, concrete worker and glass installer; common external factors; falls of persons including accidents of scaffolds, accidents involving ladders, and accidents in roof work; accidents in excavation; accidents with construction machines including data on the design of cranes; back injuries; hand tools; use of personal protective equipment; and the use of economic incentives to safety and company attitudes including safety motivation and risk perception.

Holmstrom, E.; Lindell, J.; Moritz, U. Are there any construction workers without low back pain? Bygghalsan Bulletin. 1991-09-16.

Note: English Abstract.

An abstract of a survey of back pain among 1,773 randomly selected

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construction workers which showed 88% had experienced low back pain.

Holmstrom, E.; Lindell, J.; Moritz, U. Low back and neck/shoulder pain in construction workers: occupational workload and psychosocial risk factors. Part 2: Relationship to neck and shoulder pain. *Spine*. 1992; 17(6): 672-77.

The prevalence rate of neck and shoulder trouble and considerable neck and shoulder pain in a randomly selected sample of 1773 construction workers were studied. The relationship to physical and psychosocial factors was analyzed. The workers answered a postal questionnaire. Workload was measured by means of eight manual materials handling indices and ten psychosocial indices, based on results from factor analyses. The 1-year prevalence rate of considerable neck and shoulder trouble was 56% and of neck and shoulder pain 12%. To work with hands above shoulder level showed a dose-response relationship to both neck and shoulder trouble and neck and shoulder pain. The psychosocial factors were more prominently associated with neck and shoulder trouble and neck and shoulder pain than the physical workload factors. The psychosocial indices; psychosomatic and psychic symptoms, stress and job satisfaction showed the highest age-standardized prevalence rate ratios for both neck and shoulder trouble and neck and shoulder pain.

Holmstrom, E.; Lindell, J.; Moritz, U. Low back and neck/shoulder pain in construction workers: occupational workload and psychosocial risk factors. Part 1: Relationship to low back pain. *Spine*. 1992; 17(6): 663-71.

The prevalence rate of musculoskeletal problems, especially low back pain and severe low back pain in a randomly selected sample of 1,773 construction workers was studied. Its relationship to physical and psychosocial factors was analyzed. The workers answered a postal questionnaire. Workload was measured by means of eight manual materials handling indices and ten psychosocial indices, based on results from factor analyses. The 1-year prevalence rate of low back pain was 54% and of severe low back pain 7%. The relationship to heavy manual materials handling differed with age in such a manner that it could be interpreted as a healthy worker effect. Between severe low back pain and both stooping or kneeling a dose-response relationship was found. The most prominent of the psychosocial factors associated with low back pain and severe low back pain were the stress index and the psychosomatic and psychic indices. The age-standardized prevalence rate ratio of low back pain was 1.6 (95% confidence interval 1.4-1.8) and for severe low back pain 3.1 (95% confidence interval 2.3-4), when workers reporting "high" stress were compared to workers reporting "low" stress.

Holmstrom, E.; Moritz, U. Effects of lumbar belts on trunk muscle strength and endurance: a follow-up study of construction workers. *Journal of Spinal Disorders*. 1992; 5(3): 260-66.

The effects on maximal isometric trunk muscle strength and endurance after wearing a soft heat-retaining lumbar belt or a weightlifter's belt were studied. The soft belt (SB) study group comprised 12 construction workers with healthy backs, and the weightlifter's belt (WB) group comprised 24 construction workers with current or previous low back pain. The strength and endurance measurements were performed before the start of belt use, and after 1 and 2 months. The SB group increased the trunk flexor strength by 13% (p less than or equal to 0.01) after 2 months. The WB group increased the trunk flexor strength and endurance by 12% and 29%, respectively (p less than or equal to 0.001). No significant decrease of trunk muscle strength and endurance was found at the end of the follow-up period.

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Holmstrom, E.; Moritz, U. Low back pain--correspondence between questionnaire, interview and clinical examination. *Scandinavian Journal of Rehabilitation Medicine*. 1991; 23(3): 119-25.

The aim of this study was to analyse the correspondence between answers to a questionnaire about trouble from the musculoskeletal system, answers in a personal interview and clinical findings indicating low back disorder. The questionnaire was answered by 1,773 construction workers. Out of those, 206 workers underwent interview and clinical examination. Among those who reported no lifetime LBT in the questionnaire 63% gave the same report in the personal interview and those were all assessed negative at a blind clinical examination. Of those reporting current LBT in the interview 80% (47/59) were clinically positive. The clinical criteria used in the examination seemed to indicate lumbar painful structures. Answers to a question about functional impairment were in conformity with clinical findings. As regards answers to a question about frequency of pain and a question, in the specific Nordic questionnaire for the low back, concerning inability to do normal work the correlation to clinical findings was less apparent. Reported inability to do normal work in the questionnaire corresponded only to 43% with reported sick-leave in the interview.

Holmstrom, E.; Moritz, U.; Andersson, M. Trunk muscle strength and back muscle endurance in construction workers with and without low back disorders. *Scandinavian Journal of Rehabilitation Medicine*. 1992; 24(1): 3-10.

The aim of this study was to test the hypothesis that male workers exposed to heavy work and with no lifetime history of a low back disorder (group A) have better trunk muscle strength and back muscle endurance compared to male workers with the same work exposure but with a probable (group B) or definite low back disorder (group C). Group A (n = 42) was clinically negative on physical examination. Group B (n = 75) was clinically negative or uncertain and group C (n = 86) was clinically positive, with current or previous low back disorders occurring in both groups. Group A had a significantly higher mean intraindividual extension/flexion ratio, namely 1.29 versus 1.19, in group C. The mean values for maximum isometric trunk extension and flexion strength did not differ between the groups. The isometric trunk extensor endurance was significantly lower in group C than in both group A and group B.

Jacobsson, B.; Nordstrom, B.; Lundstrom, R. Vibrating hand-held machines in the construction industry. *Safety Science*. 1992; 15: 367-73.

The aim of this study was to investigate and measure vibration levels of the most commonly used machines within the construction industry. In the report 186 hand-held machines divided into more than 15 different machine groups have been studied. The project is a joint venture between Bygghalsan (The Construction Industry's Organization for Working Environment, Safety & Health) and the National Institute of Occupational Health.

Jeune, B. Three-year incidence of disability pensions among male members of the Danish Semi-skilled Workers' Union. *Scandinavian Journal of Social Medicine*. 1980; Suppl 16: 17-27

The aim of this study is to evaluate the age- and diagnosis-specific incidence of disability pensions awarded within a large group of working men. The study population is the 228,612 male members, aged 20-64, of Denmark's largest trade union, the Semi-skilled Workers' Union (SID), of which two thirds of the so-called unskilled male workers are members. In all 4,838 awarded disability pensions were registered in the period April 1, 1973--March 31, 1976 against 3,787

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expected, i.e., an excess of 31.7 percent. The incidence rates increase more rapidly with age for the SID than for all men in Denmark. The Standard Disability Ratio (SDR) is found for major diagnoses. The highest SDRs are found for major diagnoses of the respiratory system (183.9) and of the musculoskeletal system (169.2). For these diagnoses a "wear syndrome" is suggested, where small handicaps combined with demands for strenuous work cause a considerable reduction in capacity to work.

Klein, B.; Jensen, R.; Sanderson, L. Assessment of workers' compensation claims for back strains/sprains. *Journal of Occupational Medicine*. 1984; 26(6): 443-8. Workers' compensation claim data for 1979 obtained from the Bureau of Labor Statistics' Supplementary Data System (SDS) were utilized to examine the demographic and occupational incidence of back strains/sprains among U.S. industrial employees covered by state compensation systems. These data were combined with estimated employment figures to provide incidence ratios, which allowed better approximations of industry- and occupation- specific risk. Industries found to have the largest incidence ratios were construction (1.6 claims/100 workers) and mining (1.5 claims/100 workers). Occupations with the largest ratios were miscellaneous laborers (12.3 claims/100 workers) and garbage collectors (11.1 claims/100 workers). The 285,468 compensation claims due to back strains/sprains filed in the 26 SDS states in 1979 suggest that back injuries continue to be a large and costly problem for U.S. workers and their employers.

Malmqvist, R.; Ekholm, I.; Lindstrom, L.; Petersen, I.; Ortengren, R.; Bjuro, T.; Herberts, P.; Kadefors, R. Measurement of localized muscle fatigue in building work. *Ergonomics*. 1981; 24(9): 695-709.

The loads on the shoulder muscles of building workers were investigated by applying a new fatigue index method, for evaluation of localized muscle fatigue during work. Based on a power spectrum analysis of myoelectric signals, and calculations of spectral moments, the method enables the monitoring of changes in the propagation velocity of muscle fibre action potentials. The propagation velocity alters with the integrated response to the strain of the load on muscle metabolism and circulation. Myoelectric signals from four shoulder muscles as well as the ECG were recorded on magnetic tape at the building sites during regular daily work. For analysis, specially developed computerized procedures were used, including procedures for automatic checks of signal quality. Significant localized muscle fatigue was found in one or more muscles during a spell of work. The fatigue was particularly marked in the supraspinatus and trapezius muscles, and was seen in static work tasks even when the force exerted was small. This indicates that a stereotyped task has a greater tendency to give localized muscle fatigue than a more varied one, even if the latter is heavier. The present investigation also shows that methods measuring oxygen consumption or pulse rate are not sufficiently sensitive for monitoring the influence of localized loads. Quantitative electromyography, on the other hand, permits load measurements on single muscles.

Miyashita, K.; Morioka, I.; Tanabe, T.; Iwata, H.; Takeda, S. Symptoms of construction workers exposed to whole body vibration and local vibration. *International Archives of Occupational & Environmental Health*. 1992; 64(5): 347-51. To study the effects of construction machinery operation on subjective symptoms, a questionnaire survey was carried out among construction machinery operators by a self-reporting method. Subjects were 184 power shovel operators, 127 bulldozer operators, 44 forklift operators as operator groups, and 44 office

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workers as a control. Their ages were in a range of 30-49 years. The questionnaire contained 20 symptoms referring to fatigue, digestive problems, and upper or lower limbs or back problems. The prevalence rate and symptom characteristics were examined. The dominant symptoms of the operator groups were stiff shoulder, low back pain, and stomach symptoms. The prevalence rate of low back pain was significantly different between forklift operators and controls. No significant differences were found in the symptoms of upper limbs and fingers between operator groups and controls. The prevalence of Raynaud's phenomenon was 0.5%-2.3% in the operator groups and 2.3% in the control group.

Nagira, T. Studies on the low back pain among electric construction workers. Report 1. Effects of some factors on the low back pain. Japanese Journal of Industrial Health. 1976; 16(3): 201-11.

Note: English Abstract.

An interview study in which nearly half of the Japanese construction workers participating had back pain. The primary causes were considered to be the lifting and carrying of heavy burdens and poor work conditions. The author concludes that the construction workers were exposed to a high risk of low back pain.

Niskanen, T.; Lauttalammi, J. Accidents in materials handling at building construction sites. Journal of Occupational Accidents. 1989; 11(1): 1-17.

Note: NIOSH Abstract.

Factors influencing the occurrence of accidents in materials and structural elements handling were analyzed. Materials and structural elements handling included transporting, lifting and carrying at the construction site, storage at the worksite, the assembly and stripping of formwork, the erection of structural units, and other activities. All accident notification forms pertaining to accidents involving materials handling that had occurred in one large construction company in Finland over a 5 year period were collected for a total of 442 forms. Each of the 442 accident reports was classified according to the construction phase, the work operation, the event causing the injury, the activity at the moment of the accident, the object causing injury, the part of the body injured in the accident, the type of injury, the period of disability, the accident compensation costs paid by the insurance company, and the occupation. Of the total number of injuries, 5.5% were fractures, 19.1% were contusions, and 55.1% were sprains and strains. About 28% involved injuries to the back. The greatest risk was present during the construction of frame structures. Circumstances frequently preceding serious accidents included delayed or incomplete delivery of materials to the work site and inadequate or misunderstood communication by signs. The high number of board handling accidents found indicated that preventive measures must be developed. Of the materials handling accidents, 64% occurred during manual lifting and carrying, whereas overexertion of work movement caused 36% of the accidents. Transported or lifted materials were involved in 52% of the accidents with the most hazardous activities in this category being the handling of building boards, doors and windows, timber, and of products packed in sacks. Overexerting work movement was involved in 35.7% of the accidents with manual lifting causes accounting for 39% of these, manual carrying 36%, pulling 6%, and pushing 8%.

Occupational Health Foundation. Hazard Fact Sheet: Ergonomics in Construction. Washington, D.C.: Occupational Health Foundation; 1992.

A four page summary of ergonomic hazards associated with different types of construction work. While construction work presents many ergonomic problems

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and risks, they are not insolvable. New tools have been invented to reduce the amount of overhead or floor level work, e.g., a plasterboard lift. Materials can be better designed. For example, in Sweden plasterboard is only 3 feet wide, making it easier to carry. More materials can be moved by dollies and hoists. Changing the way work is done requires an awareness on the part of both the worker and contractor of the risks and how serious the dangers are of injury.

Occupational Safety and Health Administration. Construction Lost-Time Injuries: The U.S. Army Corps of Engineers Data Base 1984-1988. Washington, D.C.: U.S. Department of Labor/OSHA; 1992.

This report presents an analysis of data from the U.S. Army Corps of Engineers (USACE) accident investigation reports for 2,578 lost-time construction injuries and fatalities occurring at/on USACE projects within the continental U.S. for the period 1984-1988. Strains/sprains/twist were the leading nature of injury involved, accounting for 29.9% of the total. Overexertion was the cause of injury 10.6% of the time.

Occupational Safety and Health Administration. Construction Accidents: The Workers' Compensation Data Base 1985-1988. Washington, D.C.: U.S. Department of Labor/OSHA; 1992.

An analysis of nearly 360,000 worker' compensation claims for construction injuries that found 24% of these injuries (mostly sprains and strains) were due to overexertion.

Olson, P. Musculoskeletal disorders of the neck-shoulder region related to working positions in the construction industry. Bygghalsan Bulletin. 1987-05-01.
Note: English Abstract.

An abstract of a study of 2,448 male workers in the Swedish Construction Industry that answered a self administered questionnaire about how many hours/week they work with their arms above shoulder level, and if they suffer from musculoskeletal disorders in the neck-shoulder region. Working more than 10 hours/week with the arms above shoulder level significantly increased musculoskeletal neck and/or shoulder disorders in all age categories above 30 years of age. Almost 50% of the construction workers work more than 10 hours/week with arms above shoulder level, and in certain subgroups such as house-painters, insulation workers, electricians, plumbers and platers, more than 2/3s work more than 10 hours/week in such positions. These facts call for a change in working methods and organization in order to prevent further work-related disorders.

Parnianpour, M.; Campello, M.; Sheikhzadeh, A. The effect of posture on triaxial trunk strength in different directions: its biomechanical consideration with respect to incidence of low-back problem in construction industry. International Journal of Industrial Ergonomics. 1991; 8(3): 279-87.

There has been no previous study investigating the triaxial strength potentials of the trunk muscles in a pre-rotated spine. A great many lifting tasks in the construction industry occur while the trunk has already been flexed in the sagittal plane. The purpose of this study was (a) to measure the triaxial maximum isometric strength of normal male subjects in all six possible directions while standing in three different postures: 0, 20, and 36 degrees of trunk flexion; (b) to assess the effect of posture on the maximum isometric torque in all six directions. The highest maximum isometric extension and flexion torques were recorded at 36 degrees of trunk flexion - they increased by 68% and 36% with respect to upright posture. The flexion angle significantly affected the measured torques in

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the intended plane of exertion during attempted flexion and extension, while the torques in the accessory planes were affected in the attempted right and left lateral bending and axial rotation ($p < 0.05$). The results of this study conflict with the recommended lifting technique: Lift with a straight back and bent knees. The development of a triaxial trunk muscle functional capacity database is initiated.

Pizatella, T.; Nelson, R.; Nestor, D.; Jensen, R. The NIOSH strategy for reducing musculoskeletal injuries. S. Isernhagen (Ed.). *Work Injury, Management and Prevention*. Rockville, Maryland: Aspen Publishers, Inc; 1988: 39-51.

Note: NIOSH Abstract.

Efforts by NIOSH to reduce the incidence of work related musculoskeletal injuries were discussed. The scope of the musculoskeletal injury problem was summarized. As a group, musculoskeletal injuries comprise the largest percentage of occupational injuries in the United States (US) and are ranked second in NIOSH's research priorities, surpassed only by occupational lung diseases. Musculoskeletal injuries to the trunk account for approximately 32 percent of all compensable injuries and 42 percent of worker compensation costs in the US. Labor intensive industries such as mining and construction have the highest rate of compensation claims for back injuries, averaging more than 1.5 claims per 100 workers annually. The proposed NIOSH national strategy for reducing the incidence of musculoskeletal injuries was discussed. It involves improving health and hazard surveillance systems, using multilevel databases at national, state, and local levels, evaluating causes and effects by coordinating scientific disciplines, controlling occupational risk factors by redesigning jobs and tools, training workers to use techniques that do not stress the musculoskeletal system, and selecting only individuals whose work capabilities meet or exceed the biomechanical demands of the job task, fostering an increasing awareness of musculoskeletal problems, and stimulating interventions. The authors conclude that the NIOSH strategy will help identify industries and occupations having a high risk for low back injury, evaluate potential task and personal risk factors, develop and validate comprehensive clinical evaluation systems and intervention strategies for musculoskeletal injuries, and provide technical assistance and technology transfer for musculoskeletal injury control.

Robinson, J.; Shor, G. Business-cycle influences on work-related disability in construction and manufacturing. *Milbank Quarterly*. 1989; 67(Suppl 2 Pt 1): 92-113.

Business-cycle upswings generate increased hiring of inexperienced workers and speedups in production methods. The upswings, however, are also associated with sharp increases in disabling work-related injury rates. Data from California for the years from 1953 to 1985 demonstrate the cyclical sensitivity of five types of disabling occupational injuries, fatalities, and acute occupational illnesses to cyclical economic fluctuations. Public policy toward work-related disability needs to focus on macroeconomic determinants of employment and unemployment patterns, as well as on improved safety training programs and worker participation in shop-floor decision making.

Salengro, B.; Commandre, F. Musculoskeletal disorders at work in building constructions: epicondylitis and low back pains. P. Buckle (Ed.). *Musculoskeletal Disorders at Work: Proceedings of a Conference Held at The University of Surrey, Guildford 13-15 April 1987*. London: Taylor & Francis; 1987: 254-58.

Note: NIOSH Abstract.

The relationship between working conditions and the incidence of rheumatism was investigated among 4065 workers in the building trades and construction

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industry. Of these 4065 workers, low back pains were reported in 488. Among drivers of heavy machinery, 30.6 percent experienced these pains. The percentages for other workers were as follows: bricklayers, 21.0; plumbers and heating workers, 22; mechanics, 24.3; roofing felt layers, 30.7; staff and foremen, 8.4; administrators, 3.5; apprentices, 4.7; unskilled workers, 10; and professional workers, 14.8. When considering age factors and length of employment, 50 percent of those suffering low back pain were aged 40 to 50 years and drove heavy machinery or were mechanics. Nearly 50 percent of the mechanics and 40 percent of the heavy machinery drivers suffered low back pain after doing their jobs for 20 to 30 years. Forty eight percent of the house builders who were surveyed and were between 25 and 30 years of age suffered low back pain. In 13,458 examinations of those who suffered epicondylitis, 83 percent were building site workers. A physiological study was also conducted to assist in determining the movements of professional house builders. The authors conclude that epidemiological studies such as these are useful in determining what needs to be corrected and to determine what is the best way to achieve this correction.

Spear, R.; Keller, C.; Milby, T. Morbidity studies of workers exposed to whole body vibration. *Archives of Environmental Health*. 1976; 31(3): 141-5.
Insurance claims for medical services submitted on behalf of a group of workers in the construction industry were collected over a 20-month period. The morbidity experience of those workers exposed to whole body vibration was contrasted with that of an unexposed control group eligible for benefits under the same plan. Using Mantel-Haenszel adjustment for age and experience, a significantly elevated relative risk was found among the exposed group in three of the thirty disease categories studied. In no disease category did the control group possess a significantly higher risk of requiring medical services. A striking proportion of the disease categories showed an initial increase in risk for exposed workers followed by a decrease with experience. This pattern suggests a selection process in which workers leave exposed-group jobs as they become afflicted with certain disease conditions.

Stenlund, B.; Goldie, I.; Hagberg, M.; Hogstedt, C.; Marions, O. Radiographic osteoarthritis in the acromioclavicular joint resulting from manual work or exposure to vibration. *British Journal of Industrial Medicine*. 1992; 49(8): 588-93.
The hypothesis that manual work and exposure to vibration are antecedents to the development of osteoarthritis was assessed employing a cross sectional study design. The frequency of osteoarthritis in the acromioclavicular joint was studied in three groups of workers in the construction industry. Two groups were manual workers (54 bricklayers and 55 rock blasters); the third group consisted of 98 foremen. The radiographic appearance of the right and left acromioclavicular joints was classified into one of five grades of osteoarthritis. A protocol was developed to assess exposure on the basis of job title, years of manual work, total weight lifted during working life, and total hours of exposure to vibrating tools. Odds ratios for job titles (manual worker v foreman) and for years of manual work as indicators of exposure were of similar magnitude of around 2.5. Construction workers who had lifted more than 709 tonnes had an increased risk of developing severe osteoarthritis of the right acromioclavicular joint, odds ratio: 2.62 (95% confidence interval (95% CI), 1.13-6.06). The odds ratio for the left side was 7.67 (95% CI, 2.76-21.34). In the analysis of vibration exposure, workers who had been highly exposed to vibration had an odds ratio of 1.99 (95% CI, 1.00-3.92) on the right side and 2.20 (95% CI, 1.07-4.56) on the left. This effect almost disappeared after simultaneous adjustment for manual work.

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Occupational and ergonomic factors, such as the sum of lifted tonnes during working life, job title, and the sum of years of manual work seem to be risk factors for osteoarthritis of the acromioclavicular joint, whereas vibration alone was a weaker risk factor.

Stenlund, B.; Goldie, I.; Hagberg, M.; Hogstedt, C. Shoulder tendinitis and its relation to heavy manual work and exposure to vibration. *Scandinavian Journal of Work Environment & Health*. 1993; 19: 43-49.

Three categories of construction industry workers (54 bricklayers, 55 rockblasters, and 98 foremen) were compared in a cross-sectional study. In a structured interview they reported exposure to loads lifted, vibration, and years of manual work. They were also subjected to a clinical investigation including medical history and a detailed shoulder examination. Among the rockblasters 33% had signs of tendinitis in the left and 40% in the right shoulder. Among the bricklayers and foremen 8-17% had signs of shoulder tendinitis. In a multiple logistic regression being a rockblaster compared with being a foreman showed an odds ratio (OR) of 3.33 for left-sided and 1.71 for right-sided shoulder tendinitis. Vibration exposure yielded an OR of 1.84 and 1.66 for the left and right sides, respectively. Vibration exposure or work as a rockblaster seemed to be risk indicators for tendinitis of the shoulders.

Stubbs, D.; Nicholson, A. Manual handling and back injuries in the construction industry: an investigation. *Journal of Occupational Accidents*. 1979; 2: 179-90.

The incidence of all accidents, manual handling accidents, back injuries, and back injuries attributed to manual handling incidents in the building and construction industry have been investigated. Employees in trades classified as involving heavy physical labour were found to be most at risk, and in all trades those under 30 years of age had higher incidences than those in older age groups. Of manual handling accidents observed, 50.3% were caused by lifting/loading and lifting/carrying, and 73.1 of back injuries attributed to handling incidents were specifically linked to these same activities. It is argued that back injuries arise either as a result of an acute gross injury, or as the cumulative effect of a series of smaller excessive strains. The results are discussed and compared with parallel studies in other industries.

Stubbs, D.; Osborne, C. How to save your back: a comparison between the nursing profession and construction industry. *Nursing - Oxford*. 1979; 3: 116-24.

Vingard, E.; Alfredsson, L.; Fellenius, E.; Hogstedt, C. Disability pensions due to musculo-skeletal disorders among men in heavy occupations: a case-control study. *Scandinavian Journal of Social Medicine*. 1992; 20(1): 31-36.

The relative risk of disability pension due to musculoskeletal disorders has been studied with regard to occupation and work load. The study population comprised men born 1915 to 1934, living in Stockholm county. 1307 men who received a disability pension during 1979, 1980, 1981 and 1984 due to disorders from the low back, neck/shoulder, hip, and knee were compared with 298 randomly selected men concerning occupation and occupational work load. Disability pensions were more common both in men with medium and high physical work load compared to men with low physical work load. Construction workers and metal workers had high relative risks of receiving disability pensions because of disorders in all four body regions, and men in many other occupations had disorders in two or three regions. In office workers the risk of disability pension because of musculo- skeletal disorders was low.

CONSTRUCTION WORK--NEW BUILDING

Vingard, E.; Alfredsson, L.; Goldie, I.; Hogstedt, C. Occupation and osteoarthritis of the hip and knee: a register-based cohort study. *International Journal of Epidemiology*. 1991; 20(4): 1025- 31.

A register-based cohort study was performed to investigate if men and women in certain occupations with high physical workload had increased risks of developing severe symptomatic osteoarthritis of the hip and knee, resulting in hospital care. The study population consisted of 250,217 people from the 1980 census, in blue-collar occupations, who had reported the same occupation in the 1960 and 1970 censuses. The study population was followed for hospital care for osteoarthritis of the hip and knee during 1981- 1983 by linkage to the Swedish Hospital Discharge Register. Different blue-collar occupations were classified as high or low with regard to exposure to forces acting on the hip and knee and the frequencies of the outcomes were compared. Male farmers, construction workers, firefighters and some food processing workers had an excess risk of hospitalization due to osteoarthritis of the hip. Male farmers, construction workers and firefighters also had increased risks of osteoarthritis of the knee. Female mail carriers had an excess risk of osteoarthritis of the hip, and female cleaners, of osteoarthritis of the knee. The findings support the hypothesis that heavy physical work load contributes to osteoarthritis of the hip and knee.

Yoshida, T.; Goto, M.; Nagira, T.; Ono, A.; Fujita, I.; Goda, S.; Bando, M. Studies on low-back pain among workers in small scale construction companies: Report 1. Analysis of clinical and radiological findings. *Japanese Journal of Industrial Health*. 1971;13(1): 37-45.

Note: English abstract.

A clinical study among Japanese workers at small-scale construction companies that yielded the following results: 45% of the workers complained of low back pain, and 33 % of the workers with low back pain reported a history of accidental incidents that affected the low back. The workers suffering from back pains had many symptoms diagnosed in other musculoskeletal organs, e.g., the upper and lower limbs. The findings showed that accidents and lasting strain caused by poor work conditions were the most important causes of back pain.

CONSTRUCTION WORK--NEW BUILDING

Schneider, S.; Susie, P. *Ergonomics and Construction: A Review of Potential Hazards in New Building Construction*. Washington, D.C.: Center to Protect Workers' Rights; 1993. 59 pages.

Ergonomics is a growing field within occupational safety and health. Ergonomic hazards are those where the design of the work or workplace causes injury, e.g., musculoskeletal problems. Injury rates attributable to ergonomic hazards are skyrocketing, accounting, for the first time, the majority of "occupational diseases" in the 1989 annual survey by the U.S. Bureau of Labor Statistics. While interest and attention has been growing, most of the focus has been on industrial and office workers. Almost no research has been done in the U.S. on ergonomic problems for construction workers. This paper is a review of potential ergonomic hazards in construction work. It summarizes the findings from published literature reports as well as findings from a year-long investigation of health hazards on a new construction site in suburban Washington, D.C. The review is structured to follow the sequence of events in the construction of a new building. The review will also, simultaneously, refer to ergonomic solutions that exist, where they have been developed or devised. This review will only deal with the hazards of new

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construction. Renovation of existing structures, the segment of the work which is growing, is not discussed here. Many of the same problems and principles apply however. [Submitted for publication to the American Industrial Hygiene Association Journal.]

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Bergoo, W. Operator seats -- a neglected work environment. *Bygghalsan Bulletin*. 1987-05-01.

Note: English Abstract.

An abstract on the problem of seat design for operating engineers, e.g., crane operators. Over the past ten years more and more employees in the construction industry have started using their vehicles as a more or less continuous place of work. Many operators have had problems with their seats after 6 to 12 months in the form of collapsed stuffing and broken springs. The author, after examining a large number of mass-produced special seats, found that after one year none of them satisfied the requirements that should be made on an acceptable professional operator's seat.

Bongers, P.; Boshuizen, H.; Hulshof, C.; Koemeester, A. Back disorders in crane operators exposed to whole-body vibration. *International Archives of Occupational & Environmental Health*. 1988; 60(2): 129-37.
In The Netherlands so far little research has been carried out to investigate the health effects of exposure to whole-body vibration at work. In a retrospective (10-year) follow-up study, the incidence of permanent work disabilities in crane operators exposed to vibration was compared to that of a control group. The emphasis in this presentation is on disablement because of back disorders. Among the crane operators with more than 5 years of exposure to vibration, more disability due to back trouble occurred than in the control group. The incidence density ratio (IDR) exceeded 2 for disability because of degeneration of the intervertebral disc, after adjustment for age, nationality, shift work and calendar year. With increasing years of exposure, the risk ratio for disability because of intervertebral disc disorders also increased. The risk ratio for a disability pension due to disease of the intervertebral disc for crane operators with more than 5 years of exposure was almost 3 compared to the control group. A combination of exposure to whole-body vibration, an unfavorable posture, and climatic conditions is responsible for the development of these health effects.

Bongers, P.; Boshuizen, H.; Hulshof, C.; Koemeester, A. Long-term sickness absence due to back disorders in crane operators exposed to whole-body vibration. *International Archives of Occupational & Environmental Health*. 1988; 61(1-2): 59-64.

In a retrospective (10-year) follow-up study, the incidence of at least one spell of sickness absenteeism of 28 d or longer in crane operators exposed to whole-body vibration and a control group was investigated. In contrast to a previous study on permanent work disability in the same groups, no difference was observed in long-term sickness absenteeism because of lumbar disorders. Spells of sickness absence due to intervertebral disc disorders did last longer in the index group and also more disability pensions with this diagnosis were recorded in the index group. This indicates that these disorders particularly interfere with the work of a crane operator. Exposure to whole-body vibration and strained posture are considered to be responsible for this situation.

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Boshuizen, H.; Bongers, P.; Hulshof, C. Self-reported back pain in tractor drivers exposed to whole-body vibration. *International Archives of Occupational & Environmental Health*. 1990; 62(2): 109-15.

A postal questionnaire on symptoms of ill health and exposure to whole-body vibration was completed by 577 workers (response rate 79%) who were employed in certain functions by two companies 11 years before. The relation between the occupational history of driving vibrating vehicles (mainly agricultural tractors) and back pain has been analyzed. The prevalence of reported back pain is approximately 10% higher in the tractor drivers than in workers not exposed to vibration. The increase is mainly due to more pain in the lower back and more pain lasting at least several days. A vibration dose was calculated by assigning each vehicle driven a vibration magnitude, estimated on the base of vibration measurements. The prevalence of back pain increases with the vibration dose. The highest prevalence odds ratios are found for the more severe types of back pain. These prevalence odds ratios do not increase with the vibration dose. This might be due to health-related selection which is more pronounced for severe back pain than for back pain in general. The two components of the vibration dose, duration of exposure and estimated mean vibration magnitude, have also been considered separately. Back pain increases with duration of exposure but it does not increase with the estimated mean magnitude of vibration. This is probably due to the inaccuracy of this estimate. The higher prevalence of back pain in tractor drivers might be (partly) caused by whole-body vibration, but prolonged sitting and posture might also be of influence.

Boshuizen, H.; Bongers, P.; Hulshof, C. Self-reported back pain in fork-lift truck and freight-container tractor drivers exposed to whole-body vibration. *Spine*. 1992; 17(1): 59-65.

To study the long-term health effect of whole-body vibration, a questionnaire on symptoms of ill health was mailed to 242 drivers and a reference group of 210 workers from six harbor companies (response 81%). Vehicles driven were fork-lift trucks and freight-container tractors. Vibration level during a representative working period (vector sum of the frequency weighted acceleration in the x-, y-, and z-directions) was 0.8 m/sec² for the fork-lift trucks and 1.0 m/sec² for the freight-container tractors. Only the results concerning self-reported symptoms of the back are described. Of the young (less than 35 years), short-term-exposed drivers, 68% reported that they had back pain regularly vs. only 25% of the reference group of comparable age. With increasing age, the difference in the prevalence of self-reported regular back pain between the drivers and the reference group disappeared. Driving during the 5 years preceding the onset of symptoms seemed to increase the risk of back pain, whereas earlier exposure did not.

Boshuizen, H.; Hulshof, C.; Bongers, P. Long-term sick leave and disability pensioning due to back disorders of tractor drivers exposed to whole-body vibration. *International Archives of Occupational & Environmental Health*. 1990; 62(2): 117-22.

In a historical 11-year follow-up study, disability pensioning and the incidence of the first sick leave of 4 weeks or longer due to back disorders has been investigated in a group of drivers exposed to whole-body vibration (WBV), mainly of agricultural tractors. The reference group comprised workers not or only slightly exposed to WBV from the same and another company. The vibration exposure of the tractor drivers was roughly around the ISO-2631 fatigue-decreased proficiency limit. The incidence of a first long-term sick leave due to

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back disorders was 3 per 100 person-years in tractor drivers and 2 per 100 person-years in the entire reference group. However, the incidence was not substantially increased in tractor drivers when the referents comprised only those working at the same company, suggesting selection bias. The highest relative risk (ca. 3) was found for long-term sick leave due to intervertebral disc disorders and this risk seemed to increase with the received WBV dose. That especially the incidence of intervertebral disc disorders increased, agrees well with findings in other studies. Data on disability pensioning due to back disorders are too scarce to be conclusive, but a trend towards younger disablement in tractor drivers is evident. Exposure to WBV, together with twisted posture and prolonged sitting, are considered to be responsible for the increased incidences observed in tractor drivers.

Brendstrup, T.; Biering-Sorensen, F. Effect of fork-lift truck driving on low-back trouble. *Scandinavian Journal of Work, Environment & Health*. 1987; 13(5): 445-52.

In a population of 240 male fork-lift truck drivers who drove at least 4 h daily, the occurrence of low-back trouble was studied in relation to that of two reference groups. The participation rate of the fork-lift truck drivers was 88%. The responses to a questionnaire concerning low-back trouble were reviewed. Among the fork-lift truck drivers, a statistically significant higher occurrence of low-back trouble was reported for the year preceding the study, in comparison, according to age, to that of a reference group of 399 working men (65 against 47%); however, there was no significantly increased frequency when compared to that of a reference group of 66 unskilled male workers (65 against 51%). The fork-lift truck drivers had a significantly higher rate of absence from work within the previous year due to low-back trouble than the two reference groups (22% compared to 7 and 9%). These findings were confirmed during the follow-up year. A correlation was found between length of employment as a fork-lift truck driver and the occurrence of low-back trouble within the preceding year. It was concluded that fork-lift truck driving may be a contributory cause for low-back trouble.

Burdorf, A; Zondervan, H. An epidemiological study of low-back pain in crane operators. *Ergonomics*. 1990; 33(8): 981-87.

A survey among workers in a steel factory was conducted to determine the risk for low-back pain (LBP) among male crane operators. Crane operators (n = 33) were matched for age with male control workers (n = 30) and examined for frequency and nature of LBP by the on-site medical service. Comparison between crane operators and controls showed a statistically significant odds ratio for LBP of 3.6. Although crane operators had been exposed more often to backstraining factors in previous occupations, in the employed logistic analysis only their current job explained the elevated occurrence of LBP. It is suggested that workers in sedentary position with exposure to whole-body vibration are at special risk for LBP. The results of this study provide evidence to strongly recommend persons with a history of back complaints not to seek employment as crane operators.

Dupuis, H.; Zerlett, G. Whole-body vibration and disorders of the spine. *International Archives of Occupational & Environmental Health*. 1987; 59(4): 323-36.

This cross-sectional study is based on interviews and medical examinations of 352 operators of earth-moving machines who had been exposed to whole-body vibrations for at least three years. In addition, available X-rays showing different parts of the spines of 251 machine operators who had been exposed to vibration for at least ten years were used for evaluation. One hundred and forty-nine of the

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operators were asked about discomfort occurring immediately after an eight-hour work shift. The group of exposed persons was compared with a control group of 215 non-exposed persons. The percentage of subjects reporting spinal discomfort was much higher for the exposed group than for the non-exposed group. 68.7% of the operators complained of spinal discomfort in the lumbar spine, 6.8% in the thoracic column and 18.2% in the cervical column. The discomfort reported immediately after an eight-hour exposure to whole-body vibration was highly age-dependent. The epidemiological study resulted in an objective confirmation of the spinal discomfort reported, 2/3 of which were related by the operators to the lumbar syndrome. Lumbar syndrome (81%) accounted for by far the highest number of spinal disorders. Examinations of the operators with at least ten years of exposure to whole-body vibrations showed that morphological changes in the lumbar spine occur earlier and much more frequently than in the case of non-exposed persons. Problems of etiology and pathogenesis are discussed.

Eklund, J.; Zettergren, S.; Odenrick, P. Evaluation of work postures. I. A model for evaluation of seated work tasks. P. Buckle (Ed.). *Musculoskeletal Disorders at Work: Proceedings of a Conference Held at The University of Surrey, Guildford 13-15 April 1987*; 1987. London: Taylor & Francis; 1987: 50-55.

Note: NIOSH Abstract.

A model was developed for the evaluation of work tasks performed while seated. The model incorporated demands and restrictions of the task and the workplace, for example, a space limitation. One of the major influences on the postures chosen to do the work was the visual demand of the task. Another was the demand for hand manipulation. The model has been applied to such tasks as grinding, punch press work and fork lift driving. The work situations were evaluated with models for the analysis of biomechanical loads, spinal shrinkage, postures, and subjective responses. The usefulness of the model in analyzing the work of a crane driver was detailed. The task of the operator was divided into two factors: visual control and operation of the crane. The visual angles were controlled primarily by two factors: first, the position of certain key objects including the goods to be lifted, the lifting device, and other areas which need to be overviewed, and second, the position of the crane driver seat. The task of the crane driver was difficult and required that hard to hold postures be maintained during long periods of time. The authors conclude that such model studies as these will assist in understanding why certain work postures are chosen.

Gustafson-Soderman, U. The effect of an adjustable sitting angle on the perceived discomfort from the back and neck-shoulder regions in building crane operators. *Applied Ergonomics*. 1987; 18: 297-304.

Note: NIOSH Abstract.

Effect of an adjustable sitting angle on the perceived discomfort from the back and neck and shoulder regions was studied in three crane operators (45 to 48 years old, 10 to 21 years in the profession) working on a construction site. An adjustable seat was installed in one of the cranes. It provided infinite variation in sitting angle in all directions, neck and lumbar supports, and adjustable armrests on existing controls. The operators were studied during a 10 week period and under three different working conditions: seated in their ordinary operator's seat, seated in the test seat, and seated in another crane with an ordinary type of seat. The degree of strain discomfort was estimated with the Borg estimation scale. The number of lifts performed in the upright and in the bent forward sitting position during the day was noted. The proportion of bent forward lifts during the work period was 33 percent, with a median value of 55 lifts per day. Number of

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lifts per day varied greatly from six to 170. The highest estimated discomfort values were reported by two subjects during test periods in an ordinary seat and with a high proportion of lifts close to the crane. When the subjects were seated in the test seat, the discomfort reported was very, very weak or scarcely perceptible (0.5 on Borg's scale). When subjects had to use another crane with an ordinary fixed seat, they tended to report more discomfort. The author concludes that for the rebuilding of crane cabs, adjustable operator's seats can offer a good alternative to the fixed operator's seats common today.

Riihimaki, H.; Tola, S.; Videman, T.; Hanninen, K. Low-back pain and occupation. A cross-sectional questionnaire study of men in machine operating, dynamic physical work, and sedentary work. *Spine*. 1989; 14(2): 204-9.
The frequency of sciatic pain, lumbago, and nonspecific low-back pain (LBP) and factors related to these symptoms were determined among men occupied in machine operating (541 longshoremen and 311 earthmover operators), dynamic physical work (696 carpenters), and sedentary work (674 municipal office workers). Sciatic pain was more common among machine operators and carpenters than among office workers, and also more frequent among machine operators than among carpenters. The occupational differences were considerably smaller with regard to lumbago and nonspecific LBP. In multivariate analysis, occupation, age, reported back accidents, and postural load showed significant independent effects on the occurrence of sciatic pain. Allowing for other risk indicators, the relative risk was 1.3 contrasting machine operators with both office workers and carpenters, but carpenters had no excess risk as compared with office workers.

Roger, Mats. Neck and shoulder problems in tractor drivers. *Bygghalsan Bulletin*. 91-09-16.

Note: English Abstract.

An abstract of work on reducing neck and shoulder problems in tractor drivers. The frequency of neck and shoulder problems in tractor drivers compared to white collar workers is several times higher.

Stanevich, R. A study of earthmoving and highway construction machinery fatalities and injuries. *Annals of the American Conference of Governmental Hygienists*. 1986; 14: 703-10.

This report summarizes a statistical analysis of 13,764 injury and fatality cases, collected by the Mine Safety and Health Administration (MSHA) from 1978 to 1983, involving heavy construction earthmoving equipment. Sprains/strains are the leading nature of injury representing 29.1% (4003) of the total worker injuries. The leading part of the body injured was the back which was injured 17.8% (2454) of the time. Cross-analysis of these two variables indicated that 43.0% of all sprain/strains affect the back. Equipment operators suffered 57.1% (2287) of the sprain/strain injuries. The author concludes that an ergonomic study of the operators work zone should be performed. The high incidence of back sprains/strains while operating equipment is presumed to result from poor ergonomic design of the operators seat in relation to the tasks the operator must perform. In addition, the operators are exposed to constant vibration forces which may have a role in these types of injuries.

Tola, S.; Riihimaki, H.; Videman, T.; Viikari-Juntura, E.; Hanninen, K. Neck and shoulder symptoms among men in machine operating, dynamic physical work and sedentary work. *Scandinavian Journal of Work, Environment & Health*. 1988; 14(5): 299-305.

CUMULATIVE TRAUMA DISORDERS

Data on the occurrence of neck and shoulder symptoms and some qualities of work and leisure-time activities were gathered with a postal questionnaire sent to 1,174 machine operators, 1,045 carpenters, and 1,013 office workers. They were all men in the age range of 25-49 years. The response rate was 67-76%. The lifetime cumulative incidence of neck and shoulder symptoms was 81% for the machine operators, 73% for the carpenters, and 57% for the office workers. About half of the two groups of manual workers and 24% of the office workers had had symptoms during the last 7 d. Pain in the arms was indicated by 14-17% of the manual workers and 4% of the office workers. Symptoms during more than 30 d within the last 12 months were also more common among the manual workers than among the office workers. Within the manual worker groups, the machine operators had more symptoms than the carpenters. In a multivariate logistic regression analysis occupation, working in twisted or bent postures, age, draft, and job satisfaction proved to be significant risk indicators for neck and shoulder symptoms.

Zettergren, S.; Eklund, J.; Odenrick, P. Evaluation of work postures. III. Workplace design for crane drivers in a steelworks. P. Buckle (Ed.). *Musculoskeletal Disorders at Work: Proceedings of a Conference Held at The University of Surrey, Guildford 13-15 April 1987*. London: Taylor & Francis; 1987: 62- 67. Note: NIOSH Abstract.

Work postures were compared in a conventional crane design in which the cabin and the lifting devices were constructed as a whole unit, and in a redesigned crane with the cabin separately movable and turnable. The redesigned cabin was also equipped with an improved chair and a new operating lever design. Lift frequencies and work load were similar for the two crane operators participating in the study. Both were women. The most dramatic differences occurred in the trunk flexion and in head rotation. A decrease in strenuous postures was clearly noted for the operator using the redesigned cabin. The need for the operator to assume a posture having a trunk flexion of 20 degrees or more decreased from 69 to 42 percent of the analyzed time. Improvements in head flexion/extension were less clear. Time spent in the position of lateral flexion of the head to the right 5 degrees or more decreased from 20 to 2 percent. Lateral flexion of the head to the left 5 degrees or more decreased from 40 to 6 percent of the time. Rotation of the head to the right by 15 degrees or more decreased from 31 to 15 percent of the time and to the left, 43 to 6 percent. It was noted that, in the conventional crane, it was common for the vision to be directed downward, causing substantial forward bending of the trunk, but relatively little flexion of the neck. The turnable cabin appeared to be the main reason for the decreased head rotation. The movability of the cabin appeared to be the main reason for the decreased forward bending of the trunk. Other modifications included making the levers smaller, eliminating foot pedals, and adding armrests.

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Armstrong, T.; Foulke, J.; Joseph, B.; Goldstein, S. Investigation of cumulative trauma disorders in a poultry processing plant. *American Industrial Hygiene Association Journal*. 1982; 43(2): 103-16.

Cumulative trauma disorders such as carpal tunnel syndrome and tenosynovitis can be caused, precipitated, or aggravated by repeated exertions with the hand. This paper describes a study in a poultry processing factory that proceeds from an analysis of health records to an analysis of work methods, postures and

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forces. Alternative work procedures and knife designs are recommended to reduce stressful work postures and forces.

Kroemer, K. Avoiding cumulative trauma disorders in shops and offices. *American Industrial Hygiene Association Journal*. 1992; 53(9): 596-604.

Cumulative trauma disorders have been medically described for about 100 years and have been related to physical activities for nearly 300 years. Yet, avoiding these disorders in the shop and office is becoming of urgent concern only now, particularly because of the Occupational Safety and Health Administration's (OSHA's) investigation and enforcement program. Such disorders occur most often in soft tissues of the body, particularly at tendons and their sheaths. They may irritate or damage nerves and impede blood flow. They are frequent in the hand/wrist/forearm area; for example, in the carpal tunnel and in the shoulder and neck. Although controversy exists, occupational and leisure activities are generally believed to cause or aggravate cumulative trauma disorders. The major activity-related factors are rapid repetitive movements, forceful movements, static muscle loading, inappropriate body postures, vibrations, and cold. Yet, the quantitative thresholds above which cumulative trauma disorders are expected to occur are largely unknown and need to be researched. Furthermore, certain health conditions may make individuals predisposed to cumulative disorders. For most cumulative trauma disorders, physical activities and job procedures can be identified that are related to the occurrence of cumulative trauma disorders. This allows the establishment of generic and specific recommendations for the avoidance of conditions that may lead to cumulative trauma disorders in the workshop or the office.

Moore, A.; Wells, R.; Ranney, D. Quantifying exposure in occupational manual tasks with cumulative trauma disorder potential. *Ergonomics*. 1991; 34(12): 1433-53. A method of describing the musculoskeletal loads in the hand and wrist during manual tasks is presented. A profile of twelve factors is used to quantify the exposure of applicable soft tissues to modes of loading suggested as being related to a number of chronic, work-related musculoskeletal disorders such as chronic muscle strain, tenosynovitis, and carpal tunnel syndrome. These factors include estimates of tendon loads and movement, frictional work done on the tendon sheaths, and muscle activation determined using electromyography. The response of these measures to changes of force, repetition, and posture was studied using eight conditions of a simulated task utilizing a pistol grip tool. Measures of tendon frictional work and dynamic electromyographic activity best paralleled the injury outcomes of an epidemiological study using similar task definitions (Silverstein et al. 1986). This field-usable system is being used currently to investigate the relationship between occupational exposure and musculoskeletal disorders.

Putz-Anderson, V. (Ed.). *Cumulative Trauma Disorders: A Manual for Musculoskeletal Diseases of the Upper Limbs*. New York: Taylor and Francis; 1988.

Note: National Institute for Occupational Safety and Health.

This manual was developed to define cumulative trauma disorders (CTDs) in the workplace, to enable non-medical personnel to recognize them, and to present strategies for preventing their occurrence. Emphasis is placed on CTDs of the upper extremities.

Rempel, D.; Harrison, R.; Barnhart, S. Work-related cumulative trauma disorders of the upper extremity. *Journal of the American Medical Association*. 1992; 267(6): 838-42.

ELECTRICAL WORK

Cumulative trauma disorders due to performance of repetitive tasks account for more than 50% of all occupational illnesses in the United States today. Employees affected by these disorders frequently experience substantial pain and functional impairment that may require a change in occupation. For the employer, these injuries result in loss of productivity and increased costs in the form of higher medical expenses and disability payments for injured workers. Successful treatment of work-related repetitive tissue injuries depends on early diagnosis and appropriate therapy. Prevention requires identifying sites and tasks that place employees at risk of injury and supporting efforts to develop safer work environments.

ELECTRICAL WORK

Bleecker, M. Medical surveillance for carpal tunnel syndrome in workers. *Journal of Hand Surgery - St Louis*. 1987; 12(5 Pt 2): 845-48.

Carpal canal size was examined as a risk factor associated with carpal tunnel syndrome in the workplace. Seven of 14 electricians had symptoms of carpal tunnel syndrome. When cross-sectional areas were measured by computed tomography (CT), affected workers had a cross-sectional area of 1.75 +/- 0.21 cm²; control values were 2.53 +/- 0.15 cm² (p less than 0.05). Subjects with a subclinical syndrome had an area of 1.83 +/- 0.22 cm², which was similar to the group with symptoms. Wrist circumference was not a predictor of the smallest carpal canal area. Unusual bony and soft tissue structures within the carpal canal were easily identified with CT.

Bleecker, M.; Bohlman, M.; Moreland, R.; Tipton, A. Carpal tunnel syndrome: role of carpal canal size. *Neurology*. 1985; 35(11): 1599-604.

Carpal canal size was examined as a risk factor associated with carpal tunnel syndrome in the workplace. Seven of 14 electricians had symptomatic carpal tunnel syndrome. On measuring cross-sectional areas by CT, affected workers had a cross-sectional area of 1.75 +/- 0.21 cm²; control values were 2.53 +/- 0.15 cm² (p less than 0.05). Individuals with a subclinical syndrome had an area of 1.83 +/- 0.22 cm², similar to the symptomatic group. Wrist circumference was not a predictor of smallest carpal canal area. Unusual bony and soft tissue structures within the carpal canal were easily identified with CT.

Brismar, T.; Ekenvall, L. Nerve conduction in the hands of vibration exposed workers. *Electroencephalography & Clinical Neurophysiology*. 1992; 85(3): 173-76.

Symptoms of peripheral neuropathy in the hands are common among workers using vibrating tools. The mechanism for this and its relation to carpal tunnel syndrome (CTS) was studied in workers exposed to vibration at their workplace (17), along with a control group of healthy construction workers with heavy manual work but without vibration exposure (10). Patients with uni- or bilateral CTS (11) and a group of healthy volunteers without manual work (9) were included for comparison. Median nerve conduction velocities were measured both over the carpal tunnel and in a more distal segment. Vibration exposed workers had similar conduction velocities to unexposed construction workers. The subgroup of vibration exposed patients with symptoms from the hands had normal conduction in the ulnar nerve but demonstrated a decrease in median nerve conduction comparable (but less pronounced) with the CTS group. On a group basis these results indicated that the median nerve is most vulnerable for hand-arm vibrations. However, the conduction defects were not pronounced

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enough to diagnose CTS in most individual cases.

Hagberg, M.; Morgenstern, H.; Kelsh, M. Impact of occupations and job tasks on the prevalence of carpal tunnel syndrome. *Scandinavian Journal of Work, Environment & Health*. 1992; 18(6): 337-45.

In this investigation reported epidemiologic studies on carpal tunnel syndrome (CTS) (15 cross-sectional studies involving 32 occupational or exposure groups and six case-referent studies) were reviewed. The prevalence of CTS in the different occupational groups varied between 0.6 and 61%. The highest prevalence was noted for grinders, butchers, grocery store workers, frozen food factory workers, platers, and workers with high-force, high-repetitive manual movements. Odds ratios greater than 10 were reported for exposed groups in three studies. On the basis of epidemiologic and other evidence, it was concluded that exposure to physical work load factors, such as repetitive and forceful gripping, is probably a major risk factor for CTS in several types of worker populations. At least 50%, and as much as 90%, of all of the CTS cases in these exposed populations appeared to be attributable to physical work load. [Electricians, Bleecker et al. 1985 are among the study populations compared.]

Hunting, K.; Welch, L.; Cuccherini, B.; Seiger, L. Musculoskeletal symptoms among electricians. *American Journal of Industrial Medicine*. 1993; 24 (in press).

This study ascertained the presence of musculoskeletal symptoms among electricians, in order to evaluate the prevalence of cumulative trauma disorders (CTD) in this population. We adapted the CTD surveillance questionnaire used by NIOSH to assess the prevalence of neck, shoulder, elbow, hand/wrist, back, and knee symptoms in the year prior to the survey. Questionnaires were completed by 308 apprentices and journeymen enrolled in training classes at the local union hall. The participants were relatively young individuals, and 86% of the participants were currently working as electricians. Participants reported a high prevalence of symptoms which occurred more than three times during the past year or which lasted more than one week. Back symptoms and hand/ wrist symptoms were experienced most frequently -- by about half the population -- while elbow symptoms were reported by only 15% of participants. Symptom prevalence was lower, but still notable, when defined as symptoms which had occurred at least once a month or lasted more than a week in the past year. Eighty-two percent of participants reported at least one musculoskeletal symptom using the most inclusive definition, while 57% reported two or more symptoms. This survey highlights that: (1) low back discomfort is common in young construction workers, and resulted in medical care, missed work, or light duty for almost 35% of the participants; (2) neck discomfort is also very common and required doctor visits or work modification for almost one-quarter of the participants; (3) these construction workers continued to work with symptoms that are classifiable as a cumulative trauma disorder; and (4) previous acute injury contributes significantly to the presence of musculoskeletal symptoms.

Ortengren, R.; Cederqvist, T.; Lindberg, M.; Magnusson, B. Workload in lower arm and shoulder when using manual and powered screwdrivers at different working heights. *International Journal of Industrial Ergonomics*. 1991; 8: 225-35.

Note: NIOSH Abstract.

An investigation was presented on the workload on hand, shoulder and arm when using manual screwdrivers and screwdrivers powered by rechargeable batteries in typical work situations. A secondary aim was to study the effect of different types of screwdrivers and screws as well as the material into which the screws are entered. Ten male electrical installation workers aged 19 to 48

ELEVATOR CONSTRUCTION

participated in the investigation. During the experiments a rechargeable screwdriver, Panasonic EZ 570, and an ordinary screwdriver, Bahco 8155, were used in a simulation of assembly operations performed in electrical installation work. To measure the muscular load, myoelectric signals from the extensor carpi radialis brevis, the flexor digitorum superficialis and the trapezius pars descendens of the stronger or preferred arm were recorded. The results indicated that the workload when inserting screws manually was high enough to cause symptoms of overload disorders. Battery powered screwdrivers reduce the load in the forearm to more favorable levels at all working heights. In the shoulder working height and screw type have greater influence. Axial force and ratings of perceived exertion were significantly lower with TORX type screws. Use of a powered screwdriver consistently increased the work pace. The results also indicated that many factors influenced the workload and sometimes interacted. These factors must be considered when inserting screws in construction work.

ELEVATOR CONSTRUCTION

Hammarskjold, E.; Henriksson, K. The work environment of lift installers. Bygghalsan Bulletin. 1987-05-01.

Note: English Abstract.

An abstract of work showing a high rate of musculoskeletal disorders among elevator constructors. A high frequency of back trouble (67%), knee trouble (45%) and foot trouble (21%) during the year before answering the questionnaire was noted. These frequencies were higher than expected, compared with other construction workers.

ERGONOMIC JOB ANALYSIS

Anderson, C.; Fine, L.; Herrin, G.; Sugano, D. Excess days lost as an index for identifying jobs with ergonomic stress. *Journal of Occupational Medicine*. 1985; 27(10): 740-44.

A new health impact index, excess cost, is advocated for identifying jobs in need of further study regarding ergonomic problems. The excess cost index is compared with incidence rate, excess count, and severity rate indices in terms of concept and appropriateness to the purpose. The four indices are illustrated with data regarding medical leave from an automobile assembly plant and evaluated in terms of ability to identify jobs most strongly contributing to excessive days lost.

Armstrong, T.; Radwin, R.; Hansen, D.; Kennedy, K. Repetitive trauma disorders: job evaluation and design. *Human Factors*. 1986; 28(3): 325-36.

Repetitive trauma disorders of the upper extremity are a major cause of lost work in many hand-intensive industries. Reported risk factors include repetitive and forceful exertions, certain postures, mechanical stress, low temperatures, gloves, and vibrations. Risk factors can be identified with job analysis procedures based on traditional work-methods analysis. Risk factors can be controlled through reallocation of work, balancing of tools, selection of alternative tool designs, work relocation, selection of suitable hand protection, and elimination of hand-exposure to low temperatures and vibration. Drawing-board manikins are used with computer-aided design systems to estimate the best work location for a

ERGONOMIC JOB ANALYSIS

given task.

Keyserling, W.; Armstrong, T.; Punnett, L. Ergonomic job analysis: a structured approach for identifying risk factors associated with overexertion injuries and disorders. *Applied Occupational & Environmental Hygiene*. 1991; 6(5): 353-63. Overexertion injuries and disorders, such as low back pain, tendonitis, and carpal tunnel syndrome are the leading cause of work-related disabilities and Workers' Compensation costs in the United States and other industrialized nations. These injuries and disorders have been associated with six generic categories of ergonomic risk factors which are found in a broad spectrum of manufacturing and service jobs: 1) forceful exertions, 2) awkward work postures, 3) localized contact stresses, 4) whole-body or segmental vibration, 5) temperature extremes, and 6) repetitive motions or prolonged activities. Once recognized and evaluated, ergonomic principles can be applied to reduce exposures to these risk factors as part of a comprehensive program to control overexertion injuries. A structured job analysis procedure has been developed to assist occupational health and safety professionals in the recognition and evaluation of exposures to ergonomic stresses in the workplace. This procedure is based on systems safety analysis techniques and utilizes a pro-active team approach to develop a detailed and open-ended evaluation of facilities, equipment, tools, processes, and work methods to recognize and evaluate specific work activities associated with potentially harmful exposures to generic risk factors.

Mattila, M. Improvement in the occupational health program in a Finnish construction company by means of systematic workplace investigation of job load and hazard analysis. *American Journal of Industrial Medicine*. 1989; 15(1): 61-72. The aim of the present study was to improve an occupational health program by means of systematic workplace investigations. The 8-month study was done at three building sites of one construction firm. The method for workplace investigations was a simple job hazard analysis of chemical hazards, physical hazards, physical work load, mental stress, and risk of injury, each factor being rated on a three-point scale. Information was gathered by observations, interviews, and a worker questionnaire. Occupational health and safety personnel and worker representatives dealt with problems cooperatively. Together they assessed occupational loads and hazards, whereafter the occupational health and safety personnel devised an occupational health care program and proposed preventive measures. The workplace investigation method proved to function well. It improved the occupational health care program, produced an overall analysis of occupational hazards, and dramatically increased the number and quality of proposed preventive measures. The new method was evaluated to be clearly superior to previous practices and was implemented at moderate cost. The study showed that attention to issues of environmental and occupational health can effectively prevent health impairment even in difficult settings such as construction work. More research is needed for effective utilization of information accumulated by systematic workplace investigations.

Mattila, M.; Kivi, P. Hazard screening and proposals for prevention by occupational health service: an experiment with job load and hazard analysis at a Finnish construction company. *Journal of the Society of Occupational Medicine*. 1991; 41(1): 17- 22. In this study a systematic method for workplace investigation was developed and then tested as part of the regular occupational health care procedures in the building trade. Workplace investigation is a concept which entails the analysis of hazards inherent in the work as well as assessment of their effects on workers'

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well-being. The aim of this paper is to evaluate the effectiveness of the workplace investigation method. The newly developed method, called Job Load and Hazard Analysis, has the following characteristics: a job analytic approach; the application of group problem-solving; and cooperation between occupational health professionals, occupational safety personnel, and line management. The method comprises the identification of health hazards, their assessment, and conclusions and proposals as to their prevention and follow-up. The method was tested as part of one constructor's actual occupational health care programme, over a 2.5-year period. The method worked well as a central component of preventive occupational health care. It yielded concrete data that could be applied to make the occupational health care programme better suited to preventing the hazards inherent in the building trade. The contents of the occupational health care programme were clearly enhanced, the number of preventive measures increased, and the organizational climate improved; the workers praised the increased emphasis on safety. More research is needed, eg in other production settings and to determine the most effective utilization of the data gathered by the method.

Ulin, S.; Armstrong, T. A strategy for evaluating occupational risk factors of musculoskeletal disorders. *Journal of Occupational Rehabilitation*. 1992; 2(1): 35-50.

There is a large and increasing incidence of work-related musculoskeletal disorders, both upper extremity cumulative trauma disorders and low back pain. Several occupational risk factors have been linked with the development of musculoskeletal disorders. In order to identify the known occupational risk factors associated with a specific job, an analysis procedure is described to help identify ergonomic risk factors in the workplace. Job analysis should be one part of an overall ergonomics control program. Once the ergonomic risk factors have been documented, the ergonomics committee can use that information to begin developing solutions that will decrease or eliminate the identified risk factors. When placing a worker who is returning to the workforce after recovering from an injury, health care professionals can also use the information from the job analysis to assist in matching up task demands with worker capabilities and limitations.

Wangenheim, M.; Samuelson, B. Automatic ergonomic work analysis. *Applied Ergonomics*. 1987; 18: 9-15.

To reduce occupation-related diseases, injuries and impairments to the musculoskeletal system, and ergonomics analysis of the work process is necessary. The authors describe a project to develop an automatic ergonomic work analysis method using existing and developed models of work stress factors. It was designed to record the work accurately without disrupting activities, and describe the situation so that production engineers and designers can be supplied with basic information for ameliorative measures. The system determines such parameters as the position and movement of 14 parts of the body and such measurements as force exerted, range of movement and static stress. A pilot study with a prototype of the system has been completed and tested with simple word sequences.

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Andersson, P. Manual screw tightening with and without micro pauses. *Bygghalsan*

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Bulletin. 1991-09-16.

Note: English Abstract.

An abstract of a study on the effect of micro pauses on stress among workers using screwdrivers. The author cites a survey that shows almost 50% of construction workers work more than 10 hours a week with their arms above shoulder level. This means an increased risk of musculoskeletal problems in the neck and shoulders. Sickleave due to these problems increases for individuals over 30 in all trade categories in the construction industry. The results of this study showed that the muscular load on the neck, shoulder and lower arm muscles is reduced when pauses are used. Perceived exertion and total working time were also clearly reduced. The experiment also showed that the construction workers themselves thought it took longer to carry out the work using micro pauses than without. When giving information about micro pauses it is important to point out that the worker does actually work faster despite experiencing quite the opposite.

Cederqvist, T.; Lindberg, M.; Linderhed, H. Influence of work with repetitive arm elevations on EMG, contraction force and perceived exertion in the shoulder. Abstract Insant till ISB XIIIth International Congress on Biomechanics, Perth, Western Australia, 9-13 December, 1991.

Static arm postures and repetitive arm elevations in occupational work situations may induce local muscular fatigue and the development of pain in the neck and shoulder. In the Swedish construction industry the incidence of work-related complaints from the neck and shoulder is high, especially in work requiring frequent use of powered screwdrivers above the shoulder level. Besides the often high-paced monotonous temporal pattern of the work, high axial forces are required to keep the screwdriver from slipping, thus leading to high loads in the shoulder and lower arm. For a better understanding of the effects in the shoulder of a repetitive and short-cycled screwdriving task above head level, an analysis of EMG-parameters, maximum voluntary contraction and perceived exertion was performed. The decrease in MVC of shoulder forward flexion and the changes in EMG and subjective ratings suggest that the repetitive work in this study induced fatigue.

Freivalds, A. The ergonomics of shovelling and shovel design: a review of the literature. *Ergonomics*. 1986; 29(1): 3-18.

In spite of increased automation, there is still a need for muscular power and for manual tools in the modern consumer and industrial environment. Yet, although the concepts of human performance and ergonomic efficiency have been applied to various industrial tasks in recent years, they have been neglected in the design of many tools, especially shovels and spades. Therefore, the purpose of this review is to ascertain the extent to which, in the past, ergonomic principles have been applied to the task of shovelling and to the design of the shovel itself. Those design aspects which have been previously neglected, but could possibly lead to improved shovelling efficiency, are outlined as a guide for further research.

Freivalds, A. The ergonomics of shovelling and shovel design: an experimental study. *Ergonomics*. 1986; 29(1): 19-30.

In spite of increased automation, there is still a need for ergonomically designed manual tools in the modern consumer and industrial environment. For example, many studies have examined the work physiology involved in shovelling, but few have referred to the shovel-design parameters needed to make the task more efficient. To this end, a two-phase experimental study examined the effects of the

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following parameters: lift angle, the size and shape of the blade, the hollow-and the closed-back design, the handle length on shovelling performance, the energy expenditure, the predicted low-back compressive forces and the subjective ratings of perceived exertion. The results indicated the following recommendations in shovel design: a lift angle of approximately 32 degrees, a large, square-point blade for shovelling, a round-point blade for digging, a hollow-back construction to reduce weight, a solid socket for strength in heavy duty uses, a step for digging in hard soil and a long tapered handle.

Hedlund, G. A study comparing the amount of force exerted on musculoskeletal tissues when using a short versus a long handled tool. (Unpublished Paper, 1992). 11 pages.

The purpose of this study has been to examine if there is a difference in strain on the locomotive organs when using a new shovel which has an extended handle. The study was carried out in a laboratory environment with 24 male farmers, on which the angles of force in the shoulders, elbows, spine, knees and angles were measured during work with the new shovel and a typical standard model shovel. As a base for a computer based biomechanical analysis, the work was filmed. The test subjects were asked to subjectively rate the workload according to the Borg scale. The study showed clearly that the workload was reduced with the new shovel, even though the test subjects did not use the ergonomic design of the new shovel to the full extent. It would be valuable to carry out further studies where the test subjects would be given instructions and training via educational material, concerning correct work techniques.

List, E.; Wallenquist, A. Aids for the partially disabled: devices for interior installation work. Bygghalsan Bulletin. 1977-05-01.

Note: English Abstract.

An abstract of a study evaluating aids and lifting devices that would enable elderly workers in the building trade, who, as a result of pain in the shoulder-girdle, neck or back find it increasingly difficult to do their work, to continue working with the help of suitable aids.

Myers, J.; Trent, R. Hand tool injuries at work: a surveillance perspective. *Journal of Safety Research*. 1988; 19(4): 165-76.

This paper reports results of a surveillance study of work injuries caused by power and nonpower hand tools. Analyzing 129,399 case reports of hand tool injury compensation claims from the 1983 Supplementary Data System of the Bureau of Labor Statistics, the authors determined that nonpower hand tool injury rates were highest in agriculture, followed by construction, mining, and retail trades. For power hand tool injury rates, the order was: construction, agriculture, manufacturing, and mining. Among nonpower hand tools, hand knives were prominent, causing large proportions of injuries to workers in the food preparation occupations and farm laborers. Power hand tool injuries were most often associated with saws, which accounted for large proportions of injuries to lumbermen, carpenters, and miscellaneous laborers. Most injuries could be described as acute trauma involving upper extremities, but musculoskeletal injuries were also documented in substantial numbers. The authors provide suggestions for focused investigations to follow the surveillance effort reported here.

Ortengren, R.; Cederqvist, T.; Lindberg, M.; Magnusson, B. Workload in lower arm and shoulder when using manual and powered screwdrivers at different working heights. *International Journal of Industrial Ergonomics*. 1991; 8: 225-35.

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Note: NIOSH Abstract.

An investigation was presented on the workload on hand, shoulder and arm when using manual screwdrivers and screwdrivers powered by rechargeable batteries in typical work situations. A secondary aim was to study the effect of different types of screwdrivers and screws as well as the material into which the screws are entered. Ten male electrical installation workers aged 19 to 48 participated in the investigation. During the experiments a rechargeable screwdriver, Panasonic EZ 570, and an ordinary screwdriver, Bahco 8155, were used in a simulation of assembly operations performed in electrical installation work. To measure the muscular load, myoelectric signals from the extensor carpi radialis brevis, the flexor digitorum superficialis and the trapezius pars descendens of the stronger or preferred arm were recorded. The results indicated that the workload when inserting screws manually was high enough to cause symptoms of overload disorders. Battery powered screwdrivers reduce the load in the forearm to more favorable levels at all working heights. In the shoulder working height and screw type have greater influence. Axial force and ratings of perceived exertion were significantly lower with TORX type screws. Use of a powered screwdriver consistently increased the work pace. The results also indicated that many factors influenced the workload and sometimes interacted. These factors must be considered when inserting screws in construction work.

Radwin, R.; Armstrong, T.; Chaffin, D. Power hand tool vibration effects on grip exertions. *Ergonomics*. 1987; 30(5): 833-855.

Operation of vibrating power hand tools can result in excessive grip force, which may increase the risk of cumulative trauma disorders in the upper extremities. An experiment was performed to study grip force exerted by 14 subjects operating a simulated hand tool vibrating at 9.8 m/s² and 49 m/s² acceleration magnitudes, at 40 Hz and 160 Hz frequencies, with vibration delivered in three orthogonal directions, and with 1.5 kg and 3.0 kg load weights. Average grip force increased from 25.3 N without vibration to 32.1 N (27%) for vibration at 40 Hz, and to 27.1 N (7%) for vibration at 160 Hz. Average grip force also increased from 27.4 N at 9.8 m/s² acceleration to 31.8 N (16%) at 49 m/s². Significant interactions between acceleration x frequency, and frequency x direction were also found. The largest average grip force increase was from 25.3 N without vibration to 35.8 N (42%) for 40 Hz and 49 m/s² vibration. The magnitude of this increase was of the same order as for a two-fold increase in load weight, where average grip force increased from 22.5 N to 35.0 N (56%). A second experiment studied hand flexor and extensor muscle responses using electromyography for five subjects holding a handle vibrating at 8 m/s² using ISO weighted acceleration, with frequencies of 20 Hz, 40 Hz and 160 Hz, and grip forces of 5%, 10% and 15% of maximum voluntary contraction. Muscle responses were greatest at frequencies where grip force was affected, indicating that the tonic vibration reflex was the likely cause of increased grip exertions.

Radwin, R.; VanBergeijk, E.; Armstrong, T. Muscle response to pneumatic hand tool torque reaction forces. *Ergonomics*. 1989; 32(6): 655-74.

Surface electromyography was used for studying the effects of torque reaction force acting against the hand, on forearm muscle activity and grip force for five subjects operating right angle, air shut-off nutrunners. Four tools having increasing spindle torque were operated using short and long torque reaction times. Nutrunner spindle torque ranged between 30 Nm and 100 Nm. Short torque reaction time was considered 0.5 s while long torque reaction time was 2 s. Peak horizontal force was the greatest component of the reaction force acting against the hand and accounted for more than 97% of the peak resultant hand

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force. Peak hand force increased from 89 N for the smallest tool to 202 N for the largest tool. Forearm muscle rms EMG, scaled for grip force, indicated average flexor activity during the Torque- reaction phase was more than four times greater than the Pre-start and Post Shut-off phases, and two times greater than the Run-down phase. Flexor EMG activity during the Torque-reaction phase increased for increasing tool peak spindle torque. Average flexor rms EMG activity, scaled for grip force, during the Torque-reaction phase increased from 372 N for the 30 Nm nutrunner to 449 N for the 100 Nm nutrunner. Flexor rms EMG activity averaged during the Torque-reaction phase and scaled for grip force was 390 N for long torque reaction times and increased to 440 N for short torque reaction times. Flexor rms EMG integrated over the torque reaction phase was 839 Ns for long torque reaction times and decreased to 312 Ns for short torque reaction times. The average latency between tool spindle torque onset and peak initial flexor rms EMG for long torque reaction times was 294 ms which decreased to 161 ms for short torque reaction times. The average latency between peak tool spindle torque, just prior to tool shut-off, and peak final rms EMG for long torque reaction times was 97 ms for flexors and 188 ms for extensors, which decreased for short torque reaction times to 47 ms for flexors and 116 ms for extensors. The results suggest that right angle nutrunner torque reaction forces can affect extrinsic hand muscles in the forearm, and hence grip exertions, by way of a reflex response. These effects may be controlled by designing hand tools that minimize torque reaction forces transmitted to the hand using mechanical advantages provided from increased handle lengths, torque reaction bars or torque absorbing suspension systems, or minimizing muscle responses to rapid torque build-up by reducing tool spindle rotation speed.

Rosenlund, E.; Maenpaa, B.; Nilsson, H.; Persson, I. Ergonomic equipment in construction work. *Bygghalsan Bulletin*. 1987-05-01.

Note: English Abstract.

An abstract of a study on ergonomic equipment in construction work citing research showing 20% of construction workers are off the job sick more than 2 weeks per year due to back and joint problems. A survey of existing ergonomic aids shows that a number of products to make the work easier exist, but their marketing is inadequate. Only a few of these aids are present on the working sites.

Schoenmarklin, R. The effect of angled hammers on wrist motion. *Proceedings of the Human Factors Society 32nd Annual Meeting, Anaheim, California, October 24-28, 1988, Vol. 1. Santa Monica, California: The Human Factors Society; 1988: 651-55.*

This research investigated the range of wrist motion characteristics associated with the ergonomic principle of "bending the tool and not the wrist" as applied to the hammer. It is thought that bending the tool reduces wrist motion, which has been shown in the literature to be a risk factor in hand/wrist disorders, such as carpal tunnel syndrome, tenosynovitis, etc. Bent hammer handles resulted in a tradeoff in beginning and ending positions of the wrist throughout a hammering stroke. Bending the hammer handle to 20 or 40 degrees resulted in significantly less ulnar deviation than a straight hammer, but also increased radial deviation. Overall, the angular deviation from neutral position in the radial/ulnar plane was significantly less for the 20 and 40 degree hammers than for the straight hammer. This research suggests that angled hammer handles in the range of 20 to 40 degrees could possibly decrease the incidence of hand/wrist disorders caused by the use of hammers.

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- Ulin, S.; Snook, S.; Armstrong, T.; Herrin, G. Preferred tool shapes for various horizontal and vertical work locations. *Applied Occupational and Environmental Hygiene*. 1992; 7(5): 327-37.
Thirty-six subjects rated seven vertical and four horizontal positions after driving 25 screws at each of these work locations. The four horizontal work locations ranged from 13 to 88 cm and the seven vertical work locations ranged from 39 to 191 cm. Pneumatic tools (torque set to 3.2 Nm) with three varying shapes (pistol, in-line, and right-angle) were used to drive the screws into perforated sheet metal. Before rating each work combination with the Borg ten-point ratio rating scale, subjects were asked to imagine that they were an assembly line worker who was required to drive screws at that work location and with that particular tool for 8 hours. The work location/tool combination that received the lowest ratings of perceived exertion for the vertical surface were given after using the pistol tool to drive screws between 114 and 140 cm. Using the right-angle or the in-line tool to drive screws at distances between 13 and 38 cm received the lowest ratings of perceived exertion on the horizontal surface. The results compare favorably with predictions from biomechanics and anthropometric data.
- Ulin, S.; Ways, C.; Armstrong, T.; Snook, S. Perceived exertion and discomfort versus work height with a pistol-shaped screwdriver. *American Industrial Hygiene Association Journal*. 1990; 51(11): 588-94.
Seven vertical locations were rated after 36 subjects drove 25 No. 6 sheet metal screws into 18-gauge perforated sheet metal (hole size of 0.28 cm) with an air-powered pistol-shaped screwdriver at each location. The seven vertical heights ranged from 38 to 191 cm. Subjects rated each level using three psychophysical scales and were asked to imagine that they were assembly line workers required to drive screws at that work location using that particular tool for 8 hr. The three scales were the Borg 10-point ratio rating scale and two visual analogue scales. All subjects, regardless of anthropometry (5th percentile females to 95th percentile males), preferred driving screws between 114 and 139 cm. At the highest level of 191 cm, the shortest subjects disliked the level twice as much as the taller subjects. The three psychophysical scales were found to be comparable in sensitivity and use, although most subjects preferred the Borg rating scale. Future research and limitations of the current study are discussed.
- van der Grinten, M. Shovel design and back load in digging trenches. P. Buckle (Ed.). *Musculoskeletal Disorders at Work: Proceedings of a Conference Held at The University of Surrey, Guildford 13-15 April 1987*. London: Taylor & Francis; 1987: 96-101.
In an experimental field study, the effect of shovel design on back load during digging trenches in compact sand was studied. Three different designs with modestly modified length and curvature of the handle were compared to a "standard shovel." The trunk flexion and the biomechanical moment at L5-S1 were used as parameters of back load. The results showed that a new designed shovel, characterized by a relatively large curvature, is an acceptable alternative to the standard shovel. However, none of the test shovels appeared to be designed in the best possible way for digging tasks in sand with very high thrusting resistance.

HIP DISORDERS

Croft, P.; Cooper, C.; Wickham, C.; Coggon, D. Defining osteoarthritis of the hip for

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epidemiologic studies. *American Journal of Epidemiology*. 1990; 132(3): 514-22. The authors compared seven radiologic indices of hip osteoarthritis to establish which provided the best definition of the disease for epidemiologic purposes. Hip joints were assessed from intravenous urograms taken in a British hospital between 1982 and 1987 in 1,315 men aged 60-75 years. The indices examined were an overall qualitative grading of osteoarthritis, four measures of joint space, the maximum thickness of subchondral sclerosis, and the size of the largest osteophyte. Minimal joint space (i.e., the shortest distance between the femoral head margin and the acetabulum) was the index most strongly associated with other radiologic features of osteoarthritis. Among a subset of 759 men who answered a questionnaire about symptoms, the overall qualitative grading, minimal joint space, and thickness of subchondral sclerosis were the radiologic indices most predictive of hip pain. Within- and between-observer repeatability were tested in a subset of 50 subjects. Measures of joint space were more reproducible than other indices. These data suggest that, at least in men, minimal joint space is the best radiologic criterion of hip osteoarthritis for use in epidemiologic studies.

Croft, P.; Cooper, C.; Wickham, C.; Coggon, D. Osteoarthritis of the hip and occupational activity. *Scandinavian Journal of Work, Environment & Health*. 1992; 18(1): 59-63.

This case-referent study investigated the relation between hip osteoarthritis and occupational activity. The subjects were 60- to 75-year-old men who had undergone intravenous urography. Interviews were obtained for 245 cases who had a hip replacement for osteoarthritis or a joint space of less than or equal to 2.5 mm and 294 referents whose joint space was greater than or equal to 3.5 mm in both hips. No clear associations were found in an analysis of all the cases, but severe disease (hip replacement for osteoarthritis or a joint space of less than or equal to 1.5 mm) was more common in the farmers, especially in those with greater than or equal to 10 years in agricultural work (odds ratio (OR) 2.0, 95% confidence interval (95% CI) 0.9-4.4). Severe disease was also associated with prolonged standing at work (OR 2.7, 95% CI 1.0-7.3) and heavy lifting (OR 2.5, 95% CI 1.1-5.7). These associations could not be explained by obesity or sporting activity. The findings suggest an increased risk of degenerative hip disease for farmers and indicate that mechanical overloading may contribute to its pathogenesis. [The association between severe osteoarthritis of the hip and construction workers and laborers (093--098, 113; N = 9) was 1.5 OR, 95% CI 0.7-3.4. For construction workers and laborers (N = 7) with 1-9 years of employment, the OR was 3.3, CI 1.2-9.2.].

Felson, D. Epidemiology of hip and knee osteoarthritis. *Epidemiologic Reviews*. 1988; 10: 1-28.

This review has focused on the prevalence and risk factors associated with knee and hip osteoarthritis. Risk factors for knee osteoarthritis are obesity and major injury, and knee osteoarthritis probably fits into the generalized osteoarthritis diathesis. Repetitive use, such as in jobs requiring heavy labor and knee bending, probably increases the risk of knee osteoarthritis. Hip osteoarthritis is probably frequently secondary to developmental defects. As Rothman has pointed out in discussing causation, this does not necessarily mean that the same factors do not also contribute to causing hip osteoarthritis. Yet, it appears that, in many cases, developmental defects are severe enough to be sufficient causes of hip osteoarthritis. To delineate other causes, it may be necessary to examine risk factors separately in those with and in those without developmental disease. Although large epidemiologic studies are best able to identify the

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relative contributions of specific risk factors while controlling for other risk factors, new studies need to focus on important unresolved questions. First, longitudinal studies with comprehensive follow-up using repeated radiographic assessments are needed to identify factors that cause development of disease or the onset of symptoms. Second, cohorts with early and possibly asymptomatic disease need to be followed to determine the causes of progression or regression of disease and the natural history of disease. Such cohorts may include those at high risk of injury such as sports enthusiasts or manual laborers.

Vingard, E.; Hogstedt, C.; Alfredsson, L.; Fellenius, E.; Goldie, I.; Koster, M.
Coxarthrosis and physical work load. *Scandinavian Journal of Work, Environment & Health*. 1991; 17(2): 104-09.

A case-referent study was performed on the possible relationship between physical work loads and an increased risk of developing coxarthrosis. The cases were 239 male recipients of a hip prosthesis as a result of severe idiopathic coxarthrosis; the referents were 302 men randomly selected from the general population. The work load was assessed through an interview and a self-administered questionnaire on the men's specific work periods. Men highly exposed to dynamic or static work loads had an increased relative risk of 2.42 (95% confidence interval 1.45- 4.04) for developing coxarthrosis when compared with men with low exposure. Men with high exposure to heavy lifting between the ages of 30 and 49 years had the highest relative risk, 3.31 (95% confidence interval 1.97-5.57). Long-time exposure to physical work loads seems to be a risk factor for severe coxarthrosis among men.

INTERVENTION PROGRAMS

Kilbom, A. Intervention programmes for work-related neck and upper limb disorders: strategies and evaluation. *Ergonomics*. 1988 May; 31(5): 735-47.

In this review the design and results of controlled interventions against work-related neck and upper limb disorders are discussed. The method of intervention -- workstation redesign, work reorganization, worker training and education -- is related to the outcome. The results should be evaluated using a range of intermediate and end-point variables. Very little attention has yet been paid to the cost effectiveness of interventions and unsuccessful interventions are seldom reported, which makes an evaluation of the 'most successful design' incomplete. The use of reference groups for control of background variables, like fluctuations in work output and staff turnover is emphasized. The role of researchers, as active interveners or as passive recorders of effects is discussed, and the importance of an active contribution from management and employers is stressed.

Mattila, M. Improvement in the occupational health program in a Finnish construction company by means of systematic workplace investigation of job load and hazard analysis. *American Journal of Industrial Medicine*. 1989; 15(1): 61-72.

The aim of the present study was to improve an occupational health program by means of systematic workplace investigations. The 8-month study was done at three building sites of one construction firm. The method for workplace investigations was a simple job hazard analysis of chemical hazards, physical hazards, physical work load, mental stress, and risk of injury, each factor being rated on a three-point scale. Information was gathered by observations, interviews, and a worker questionnaire. Occupational health and safety personnel

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and worker representatives dealt with problems cooperatively. Together they assessed occupational loads and hazards, whereafter the occupational health and safety personnel devised an occupational health care program and proposed preventive measures. The workplace investigation method proved to function well. It improved the occupational health care program, produced an overall analysis of occupational hazards, and dramatically increased the number and quality of proposed preventive measures. The new method was evaluated to be clearly superior to previous practices and was implemented at moderate cost. The study showed that attention to issues of environmental and occupational health can effectively prevent health impairment even in difficult setting such as construction work. More research is needed for effective utilization of information accumulated by systematic workplace investigations.

Mattila, M.; Kivi, P. Hazard screening and proposals for prevention by occupational health service: an experiment with job load and hazard analysis at a Finnish construction company. *Journal of the Society of Occupational Medicine*. 1991; 41(1): 17- 22.

In this study a systematic method for workplace investigation was developed and then tested as part of the regular occupational health care procedures in the building trade. Workplace investigation is a concept which entails the analysis of hazards inherent in the work as well as assessment of their effects on workers' well-being. The aim of this paper is to evaluate the effectiveness of the workplace investigation method. The newly developed method, called Job Load and Hazard Analysis, has the following characteristics: a job analytic approach; the application of group problem-solving; and cooperation between occupational health professionals, occupational safety personnel, and line management. The method comprises the identification of health hazards, their assessment, and conclusions and proposals as to their prevention and follow-up. The method was tested as part of one constructor's actual occupational health care programme, over a 2.5-year period. The method worked well as a central component of preventive occupational health care. It yielded concrete data that could be applied to make the occupational health care programme better suited to preventing the hazards inherent in the building trade. The contents of the occupational health care programme were clearly enhanced, the number of preventive measures increased, and the organizational climate improved; the workers praised the increased emphasis on safety. More research is needed, eg in other production settings and to determine the most effective utilization of the data gathered by the method.

Snook, S. Comparison of different approaches for the prevention of low back pain. *Applied Industrial Hygiene*. 1988; 3(3): 73-78.

Three major approaches have been used to reduce the problem of low back pain: training and education, job design (ergonomics), and job placement (selection). Training is the oldest and most common approach. Teaching the worker to lift with a straight back and bent knees is one of the oldest types of training found in industry. Unfortunately, it has been difficult to prove the effectiveness of this approach in reducing compensable low back pain. More effective results have come from training the worker in strength and physical fitness and in training management on how to respond to low back pain when it does occur. The training of practitioners in treating low back pain is also important since many long-term disability cases result from inappropriate treatment and/or the prolonged use of ineffective treatment. The ergonomic approach of designing the job to fit the capabilities of the worker has received greater attention in recent years. Unnecessary bending, twisting, and reaching are risk factors to be avoided

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in good job design. Criteria for determining excessive loads have been developed for use in evaluating and designing jobs. Studies have shown that good job design can reduce up to one-third of compensable low back pain. The use of ergonomic principles in job design can reduce the probability of initial and recurring episodes, allow the worker with moderate symptoms to stay on the job longer, and permit the disabled worker to return to the job sooner. The third approach to controlling low back pain is job placement, or selection of the worker to fit the job. This approach is particularly useful for jobs that are difficult to design or control such as firefighters, police, and certain construction and delivery operations. The use of medical criteria in job placement can identify up to 10 percent of young workers susceptible to low back pain. Studies on strength testing indicate that the probability of a musculoskeletal disorder is up to three times greater when job lifting requirements approach or exceed the worker's isometric strength capability. It is concluded that there is no simple solution to low back pain and that all three approaches are necessary for the best possible control of the disorder. However, some approaches are more effective than others and should be considered first in any program to reduce low back pain. Although knowledge about low back pain is limited, enough is already known to adequately control the problem. Instead of waiting for a major medical breakthrough to occur, emphasis should be placed on applying the knowledge that is already available.

Wallace, M.; Buckle, P. Ergonomic aspects of neck and upper limb disorders.

International Reviews of Ergonomics. 1987; 1: 173-200.

This review paper considers the nature of the problem of neck and upper limb disorders with respect to the diagnoses and classification of classic musculoskeletal disorders and those which are less well defined. In particular it examines the collective terms which have arisen in recent years. Methodological difficulties in undertaking epidemiological studies of these disorders are described with reference to a number of investigations. The paper argues that at present there is a lack of theory linking specific health effects to specific causal factors, and considers the evidence for associated risk factors. Links with occupation, posture, movement and force, task dimensions, work content and psychological factors are discussed with reference to the current literature. The role of individual characteristics and the use of screening tests is similarly reviewed. The paper continues by examining the results of a number of intervention studies and examines their effectiveness. The conclusions emphasize the importance of static load and constrained postures as associated risk factors and, in addition, identify a number of areas for future research.

Wickstrom, G. Prevention of occupational back disorders - an intervention study.

Scandinavian Journal of Work, Environment & Health. 1988; 14(Suppl 1): 116-17.

Note: NIOSH Abstract.

An intervention study carried out in Finland for prevention of occupational back disorders was described. The study attempted to address all possible risk factors except psychosocial factors. Three occupations in one company and two in another were studied in order to obtain large groups with homogeneous exposure to back loads. Only male workers aged 35 to 44 were studied. In a shipyard, work planners, welders, and plumbers were studied; planners and platers were studied in a factory that produced ventilation equipment for paper machines. Initial baseline values were determined for the incidence of low back disorders and for low back loads at work. Questionnaires, interviews, and physical tests were used for determining incidence of disorders, and annual workdays lost were calculated

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for each of 2 years based on occupation, sex, and age. Physical and psychological low back loads were determined using video taping, electromyography, and questionnaires. Only some baseline results had been analyzed so far for planning of interventions. Company personnel were included in determinations of which risks to approach and how to act on them. Some practical measures had already been put into effect. Future plans for the study following completion of the intervention phase included a 3 year followup of company absenteeism registers, questionnaires measuring occurrence of symptoms, and measurement of back loads to detect any changes.

Wickstrom, G.; Pentti, J.; Hyytianen, K. Type A behaviour and back pain. *Work and Stress*. 1989; 3(2): 203-07.

Note: NIOSH Abstract.

The potential relation between back pain and competitiveness, in the form of type-A behavior, was examined in this intervention study aimed at reducing the occurrence of back pain. Four hundred and sixty one male workers representing five different occupations in the metal industry (work planners, planners, sheet metal workers, welders, and plumbers) responded to a questionnaire on competitiveness as a personality dimension and experience of back pain. Competitive behavior was found to be twice as common among sedentary employees than among manual workers. Experience of back pain radiating to a leg was more common in the manual workers with a competitive personality than in the noncompetitive ones; this relationship was not observed in sedentary employees. The authors suggest that this finding could be due to a more common occurrence of over exertion and trauma affecting the back tissues in competitive type-A workers; such workers would be more prone to use all their strength than the less competitive type-B workers, thereby predisposing them to musculoskeletal trauma. The authors propose that in the population at large, more attention should be given to leisure time activities; as for manual workers, health education on the risks of back injury should be improved parallel to attempts to reduce peak loads.

IRON WORK

Hart, D.; Link, J. Ergonomic task analysis of iron work on the James C. Davis Construction site. (Unpublished Paper, 1991). 14 pages.

A review of the ergonomic hazards encountered by iron workers in the course of the construction of a new building. Specific tasks examined were 1) raising crew, 2) bolters, 3) decking crew, and 4) welders. The review describes work postures, body movements, forces, repetition/task cycling, and equipment.

Schneider, S. Observations on ergonomic hazards at the IAM worksite. (Unpublished Paper, 1991). 3 pages.

Observations on the hazards encountered in the course of iron work, concrete work, and masonry work. Includes solutions and suggestions for ergonomic improvements.

KNEE DISORDERS

Anonymous. Protect your knees. *Bygghalsans Broschyr*. 1983; 10(1): 9 pages.

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Note: NIOSH Abstract.

Knee pain and protection are reviewed. An unprotected knee resting against a hard surface is not capable of supporting the weight of the body for any extended period of time. The contact surface is very small and the force per unit surface area becomes very large resulting in injuries to the cartilage in the knee joint. The incidences of knee pain among selected occupational groups are: floor layers, 26 percent; sheet metal workers, 17 percent; refrigeration installers, 16 percent; pipe fitters, 15 percent; electricians, 14 percent; roofers, masons, and carpenters, 13 percent; painters and concrete workers, 12.5 percent; crane operators, machine operators, stone workers, and scaffold builders, 12 percent; glass workers and insulation installers, 11 percent; foremen and drivers, 10 percent; and clerks, 5 percent. Other causes of knee pain include aging and injuries due to sports activities. Knee protection is summarized. Anyone who works in a kneeling position should use knee pads. The pads help distribute the body weight over a larger surface area, reducing the risk of knee pain. (Swedish).

Felson, D. Epidemiology of hip and knee osteoarthritis. *Epidemiologic Reviews*. 1988; 10: 1-28.

This review has focused on the prevalence and risk factors associated with knee and hip osteoarthritis. Risk factors for knee osteoarthritis are obesity and major injury, and knee osteoarthritis probably fits into the generalized osteoarthritis diathesis. Repetitive use, such as in jobs requiring heavy labor and knee bending, probably increases the risk of knee osteoarthritis. Hip osteoarthritis is probably frequently secondary to developmental defects. As Rothman has pointed out in discussing causation, this does not necessarily mean that the same factors do not also contribute to causing hip osteoarthritis. Yet, it appears that, in many cases, developmental defects are severe enough to be sufficient causes of hip osteoarthritis. To delineate other causes, it may be necessary to examine risk factors separately in those with and in those without developmental disease. Although large epidemiologic studies are best able to identify the relative contributions of specific risk factors while controlling for other risk factors, new studies need to focus on important unresolved questions. First, longitudinal studies with comprehensive follow-up using repeated radiographic assessments are needed to identify factors that cause development of disease or the onset of symptoms. Second, cohorts with early and possibly asymptomatic disease need to be followed to determine the causes of progression or regression of disease and the natural history of disease. Such cohorts may include those at high risk of injury such as sports enthusiasts or manual laborers.

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Hagberg, M. The amplitude distribution of surface EMG in static and intermittent static muscular performance. *European Journal of Applied Physiology & Occupational Physiology*. 1979; 40(4): 265-72.

A measure of the variation of load on individual muscles or parts of muscles may be obtained by estimating the amplitude probability distribution function (APDF) of the myoelectric signal. In a study of elbow flexor muscular performance in static and intermittent static low level muscular contractions, the APDF was computed from the surface EMG obtained from the belly of the brachial biceps muscle. The APDF was also computed from the simultaneously recorded force signal. The APDF of the myoelectric signal and of the force signal were similar, indicating that the APDF of the myoelectric signal closely reflects the muscular

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- load in non-fatiguing muscular contractions. The effect of the time constant in lowpass filtering when processing the surface EMG-signals was also studied. A suitable time constant appears to be in the range of 50-100 ms.
- Hagberg, M. Electromyographic signs of shoulder muscular fatigue in two elevated arm positions. *American Journal of Physical Medicine*. 1981; 60(3): 111-21.
Electromyographic signs of shoulder muscular fatigue were studied in abduction and forward flexion at right angle in the shoulder joint for seven subjects. The myoelectric signal was recorded by surface electrodes for the upper part of the trapezius muscle, the infraspinatus muscle, the middle and anterior part of the deltoid muscle and the biceps brachialis muscle. Bipolar wire electrodes were used for the supraspinatus muscle. By a moving window t-test the duration to the first significant increase of amplitude (RMS) or decrease of mean power frequency (MPF) were determined. The torque produced by the mass of the arm in the two studied elevated arm positions was found to exceed 10 per cent of the maximal voluntary contraction (MVC) for all subjects. For most subjects the supraspinatus and the upper part of the trapezius muscle, revealed significant signs of fatigue after five minutes in the two positions and short time constants of myoelectric amplitude changes. Furthermore electromyographic signs of fatigue developed within a minute for all subjects in the forward flexion (supraspinatus muscle) and in the abduction position (upper part of the trapezius muscle).
- Hagberg, M.; Michaelson, G.; Ortelius, A. Serum creatine kinase as an indicator of local muscular strain in experimental and occupational work. *International Archives of Occupational & Environmental Health*. 1982; 50(4): 377-86.
Serum creatine kinase (SCK) was measured in ten subjects in the laboratory before and after the performance of bicycle ergometry and a lifting task. SCK was significantly increased 24 h and 48 h after the lifting work but not after the bicycle ergometry, although the work performed on the latter was four-times as great as on the former. The lifting work resulted in muscle pain and tenderness and, for six subjects, in clinical signs of shoulder tendinitis. In a field study, an increase in SCK was noted among assemblers/welders and cash-register operators, but not among controllers and forklift-truck drivers. A health interview revealed that musculo-skeletal complaints were most often located in the upper extremity in the cases of the assemblers/welders and the cash-register operators. It is proposed that the SCK increase during work is a result of a high local muscular load due to fatigue and energy depletion of muscle cells producing a greater efflux of muscle enzymes. The evaluation of SCK changes during work may be an important tool in occupational health for early detection of work tasks producing local muscular strain.
- Herberts, P.; Kadefors, R.; Broman, H. Arm positioning in manual tasks. An electromyographic study of localized muscle fatigue. *Ergonomics*. 1980; 23(7): 655-65.
Myoelectric activity in four different shoulder muscles was collected and interpreted as indirect indicators of the load in eight different arm positions. The power spectrum changes associated with localized muscle fatigue were measured using a new dedicated instrument. Localized muscle fatigue was present in all muscles, in overhead and shoulder level work, and in some cases in waist level work as well. For instance, in overhead work, the supraspinatus load was significantly affected by elbow positioning. The infraspinatus muscle held the highest fatigue effects of all muscles investigated. The results indicate the possibility of finding positions entailing reduction of the total muscular load in different working situations.

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Kadefors, R. Application of electromyography in ergonomics: new vistas. *Scandinavian Journal of Rehabilitation Medicine*. 1978; 10(3): 127-33.

The application of electromyography in analysis of muscle strain in working situations is far from straight-forward. Muscle force, for instance, is not directly accessible using electromyography. New insight in electrophysiological phenomena of human muscle provides however a firm basis for analysis of localized muscle fatigue at work. Such applications entail information at the muscle fiber membrane level.

Korner, L.; Parker, P.; Almstrom, C.; Herberts, P.; Kadefors, R. The relation between spectral changes of the myoelectric signal and the intramuscular pressure of human skeletal muscle. *European Journal of Applied Physiology & Occupational Physiology*. 1984; 52(2): 202-06.

The purpose of the present study was to investigate if the intramuscular pressure generated during an isometric muscle contraction is important for the appearance of EMG spectral changes accompanying localized muscular fatigue. The EMG and intramuscular pressure of the left biceps brachii in eight volunteers were recorded during standardized isometric contractions by means of intramuscular wire electrodes and infusion catheters, respectively. Spectral changes were elicited by a submaximal contraction and the intramuscular pressure at which the induced spectral changes were able to recover was determined. It was found that significant recovery was possible only if the intramuscular pressure dropped below a level of about 2.7 kPa (20 mm Hg). It is concluded that the intramuscular pressure during a sustained isometric contraction is relevant for the generation of fatigue induced spectral changes, and that measurement of the intramuscular pressure makes possible predetermination of whether or not an isometric muscle contraction is liable to result in localized muscular fatigue.

Lindstrom, L.; Kadefors, R.; Petersen, I. An electromyographic index for localized muscle fatigue. *Journal of Applied Physiology: Respiratory, Environmental & Exercise Physiology*. 1977; 43(4): 750-54.

A new method for objective quantification of localized muscle fatigue is described. The method is based on power spectrum analysis of myoelectric signals obtained from the fatigued muscle. It permits real-time investigations and yields statistically based criteria for the occurrence of fatigue. The findings are interpreted in terms of muscle action potential conduction velocity changes and rate of the fatigue development.

Malmqvist, R.; Ekholm, I.; Lindstrom, L.; Petersen, I.; Ortengren, R.; Bjuro, T.; Herberts, P.; Kadefors, R. Measurement of localized muscle fatigue in building work. *Ergonomics*. 1981; 24(9): 695-709.

The loads on the shoulder muscles of building workers were investigated by applying a new fatigue index method, for evaluation of localized muscle fatigue during work. Based on a power spectrum analysis of myoelectric signals, and calculations of spectral moments, the method enables the monitoring of changes in the propagation velocity of muscle fibre action potentials. The propagation velocity alters with the integrated response to the strain of the load on muscle metabolism and circulation. Myoelectric signals from four shoulder muscles as well as the ECG were recorded on magnetic tape at the building sites during regular daily work. For analysis, specially developed computerized procedures were used, including procedures for automatic checks of signal quality. Significant localized muscle fatigue was found in one or more muscles during a spell of work. The fatigue was particularly marked in the supraspinatus and

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trapezius muscles, and was seen in static work tasks even when the force exerted was small. This indicates that a stereotyped task has a greater tendency to give localized muscle fatigue than a more varied one, even if the latter is heavier. The present investigation also shows that methods measuring oxygen consumption or pulse rate are not sufficiently sensitive for monitoring the influence of localized loads. Quantitative electromyography, on the other hand, permits load measurements on single muscles.

Sudhakar, L.; Schoenmarklin, R.; Lavender, S.; Marras, W. The effects of gloves on grip strength and muscle activity. Proceedings of the Human Factors Society 32nd Annual Meeting, Anaheim, California, October 24-28, 1988, Vol. 1, The Human Factors Society, Santa Monica, California. 1988: 647-50.

Note: NIOSH Abstract.

A study was made of how grip strength and forearm muscle force were affected by two types of gloved conditions and barehanded condition. Six men and six women volunteered as subjects for the study. The subjects used either rubber industrial gloves, suede leather construction gloves, or were barehanded. Anthropometric measurements were taken prior to testing the subjects. Statistical analyses were performed both on the actual grip strength as well as normalized grip strength and electromyogram (EMG). Muscle activity based on integrated EMG increased monotonically with the development of grip strength. Regardless of the type of glove worn, the subjects exerted the same level of internal muscle force. However, the amount of external grip force decreased significantly in gloved conditions. By using the efficiency scores as dependent measures, it was demonstrated that a loss in energy transfer took place at the hand glove interface. The authors caution that by using gloves in submaximal tasks, workers are likely to fatigue more quickly due to the greater muscular forces required. These reduced muscle forces will weaken the grip strength, and could cause the dropping of boxes and tools, as well as slips and falls in the workplace. Increased forces in forearm muscles could also increase the risk of cumulative trauma in the hand and wrist. The need to consider the effect of muscle force and energy transfer at the hand/glove interface when determining the suitability of a specific glove type for a specific job is stressed.

Sundelin, G.; Hagberg, M. Electromyographic signs of shoulder muscle fatigue in repetitive arm work paced by the Methods-Time Measurement system. Scandinavian Journal of Work, Environment & Health. 1992; 18(4): 262-68. Surface electromyographic (EMG) recordings from the lateral and cervical portions of the descending trapezius muscle and from the infraspinatus muscle were assessed for six female subjects performing a standardized repetitive work simulation task for 1 h. The work pace was determined according to the Methods-Time Measurement system to 2466 cycles.h⁻¹. The variation in load levels were high and indicated dynamic muscle activity. A decrease in the EMG mean power frequency and an increase in the root-mean-square amplitudes, both indicating muscle fatigue, developed in all muscles of most of the subjects. EMG signs of fatigue, analyzed separately for each 5-min period, showed variable fatigue patterns both between muscles and between subjects. It is therefore suggested that dynamic work movements do not protect the muscles of the shoulder and neck from fatiguing processes in highly repetitive work with short cycle times.

Vollestad, N.; Sejersted, O. Biochemical correlates of fatigue. A brief review. European Journal of Applied Physiology & Occupational Physiology. 1988; 57(3): 336-47. Muscle fatigue, defined as a decreased force generating capacity, develops gradually during exercise and is distinct from exhaustion, which occurs when the

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required force or exercise intensity can no longer be maintained. We have reviewed several biochemical and ionic changes reported to occur in exercising muscle, and analysed the possible effects these changes may have on the electrical and contractile properties of the muscle. There is no evidence that substrate depletion can account for the decreased force generating capacity, but this factor may be important for the rate of energy turnover and be a major determinant for endurance. Increased concentration of inorganic phosphate and hydrogen ions will depress the force generating capacity, but since fatigue can develop gradually without accumulation of these ions they can only be important when aerobic ATP production is insufficient to support the contractions. Evidence is presented showing that a disturbed balance of K^+ alone might cause depolarisation block at high stimulation frequencies, but extracellular K^+ accumulation does not increase gradually during prolonged dynamic or static exercise, and is therefore not closely related to fatigue. The repeated release of Ca^{2+} from the sarcoplasmic reticulum (SR) during muscular activity is suggested of Ca^{2+} by the mitochondria, increasing with stimulation frequency and duration and possibly also deteriorating mitochondrial function. We therefore speculate that decreased Ca^{2+} availability for release from SR might contribute to a gradual decline in force generating capacity during all types of exercise.

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Andersson, G. Epidemiologic aspects on low-back pain in industry. *Spine*. 1981; 6(1): 53-60.

The role of epidemiology with respect to back pain in industry is to clarify the natural history and clinical course of the pain and to identify workplace factors and individual factors of importance. On the basis of knowledge obtained through epidemiologic research, preventive measures can be instituted and risk factors eliminated. This paper reviews epidemiological data accumulated over the past 30 years. The impact of back conditions on industry is emphasized.

Bergenudd, H.; Nilsson, B. Back pain in middle age; occupational workload and psychologic factors: an epidemiologic survey. *Spine*. 1988; 13(1): 58-60.

The prevalence of back pain in a sample of 575 fifty-five-year-old residents of Malmö, Sweden, was studied and predisposing factors were analyzed. The point prevalence of back pain was 29%. Individuals with back pain had been less successful in a childhood intelligence test, had a shorter education and worked at physically more strenuous jobs. They were also less satisfied with their working conditions. [The study subjects were divided into three groups, light physical work, moderate physical work, and heavy physical work. The latter group included carpenters, bricklayers, and other heavy industry workers.].

Damkot, D.; Pope, M.; Lord, J.; Frymoyer, J. The relationship between work history, work environment and low-back pain in men. *Spine*. 1984; 9(4): 395-99.

Interviews were conducted with 303 men to determine aspects of work history and working environment that are related to low-back pain. Respondents included no pain, moderate pain, and severe pain samples. Data were obtained for 150 variables including task frequencies, weights lifted, lifting postures, type of floor surface, type of chair support, pushing, pulling, and carrying activities, driving vehicles, and attributions of pain occurrence to particular situations. Univariate analyses showed difference among the three pain groups for lifting method, having had lifting instruction, stretching and reaching activities, amount

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of sitting and twisting in seat, pushing materials of varied weights, and contributions of pain onset. Multivariate regression analyses selected activities from (1) standing and lifting, (2) carrying, pushing, and pulling, (3) sitting, (4) driving vehicles, and (5) using vibrating equipment that jointly explained pain group variance. The significant variables from each domain were used in second-level multiple regressions to explain differences between no pain and pain, and between moderate and severe pain. Computed weights for pulling, lifting method, weight carried, reaching and stretching, chair support, number of times/day in-out of chair, and heavy vibration exposure explained 27% of variance between moderate and severe pain groups. Weights for automobile driving, number of times/day in- out of vehicle, number of lifts/day, maximum weight pulled, sitting with feet on floor, and exposure to heavy vibration explained 23% of the variance between no pain and pain groups.

Frymoyer, J.; Cats-Baril, W. Predictors of low back pain disability. *Clinical Orthopaedics & Related Research*. 1987; (221): 89-98.

Low back pain has major socioeconomic implications; much of the costs relate to disability and compensation. Theoretically, the early identification of patients at risk to become disabled from a low back episode would lead to more aggressive intervention and reduction of subsequent disability. Low back disability is related to occupational, psychosocial, diagnostic, demographic, anthropometric, health behavior, and injury factors that have been reported in the literature. The multiattribute utility model is a new experimental approach to prediction of disability. The relative weights of the various factors that might be predictive of low back disability are determined by a panel of experts. Although this model is not yet scientifically proven, it offers a promising method of answering the question, "Can low back disability be predicted?"

Haig, A.; Linton, P.; McIntosh, M.; Moneta, L.; Mead, P. Aggressive early medical management by a specialist in physical medicine and rehabilitation: effect on lost time due to injuries in hospital employees. *Journal of Occupational Medicine*. 1990; 32(3): 241-44.

Musculoskeletal injuries to hospital workers are both common and costly. Little advice has been written on how to decrease losses after injury. In a tertiary care hospital with 2700 employees a specialist in physical medicine and rehabilitation evaluated injured employees who were out of work for more than 2 days. Physician management emphasized increasing patient investment in the problem, early assessment of delayed recovery, and effective communication with the employer. There were 61 injuries averaging 6.7 days off per injury. In a previous year, 52 injuries averaged 11.8 days. Employees out for more than 2 days with back pain and seen by the physiatrist (52%) averaged 11 days off per injury whereas others averaged 14.9 days. In this hospital, early management by a specialist resulted in a substantial decrease in time off because of injury.

Heliovaara, M. Occupation and risk of herniated lumbar intervertebral disc or sciatica leading to hospitalization. *Journal of Chronic Diseases*. 1987; 40(3): 259-64. Various occupations were studied for the prediction of herniated lumbar intervertebral disc or sciatica in 592 men and women who had been discharged from hospital with these diagnoses during an 11-year follow-up after a health examination. The cases were compared with 2140 controls matched individually for sex, age and place of residence. Subjects who, at the initial examination before the follow-up, had reported a history of back pain or sciatica were excluded. In men, the risk of being hospitalized due to herniated lumbar disc or sciatica was lowest in professional and related occupations, significantly higher in

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all other groups and highest among blue-collar workers in industry and among motor vehicle drivers. The variation in the risk between occupational groups of women proved less but was nevertheless still apparent. However, in women, but not in men, the risk was significantly associated with self-assessed strenuousness of work.

Jensen, R. Epidemiology of work-related back pain. *Topics in Acute Care Trauma Rehabilitation*. 1988; 2(3): 1-15.

Note: NIOSH Abstract.

Job factors that affect risk of back pain were reviewed. Prevalence measures have been used to categorize the proportion of individuals with back pain. These measures include lifetime prevalence, period prevalence, and point prevalence according to the time frame. The frequency of back pain episodes is characterized by incidence ratio, incidence rate, and incidence density. Several studies that varied in methods, measures, and population have shown that jobs requiring very stressful manual load handling are associated with larger incidence rates of back pain than jobs with less stressful back load requirements. Four studies found that workers who must use most of their strength to perform the job were more likely to develop back problems than those who use less strength. Workers in jobs with high accident rates were found more likely to develop back problems. Traumatic events were found to contribute substantially to the incidence of work related back pain. Jobs that require nearly all standing or sitting postures were found to be associated with larger point prevalence of back pain. The increase could be attributed to other factors, such as vibration and impact, depending on the occupation. Pushing, pulling, carrying, asymmetric lifting and lowering, twisting, and bending have been implicated in back injuries. The author concludes that the following occupational factors are associated with increased incidence of back pain: general heavy work, frequent manual load handling, occasional very stressful load handling, load handling near one's strength capacity, accidents, and prolonged standing and sitting.

Keyserling, W.; Punnett, L.; Fine, L. Trunk posture and back pain: identification and control of occupational risk factors. *Applied Industrial Hygiene*. 1988; 3(3): 87-92.

Awkward trunk posture during work can be caused by a number of controllable factors, including poor work station layout, inappropriate design of tools and equipment, and/or incorrect work methods. If not eliminated, these postures can cause fatigue and contribute to the development of pain and disorders in the lower back. A computer-aided system was developed to evaluate trunk posture during work by measuring the time spent in neutral and non-neutral postures. This system was used to assess postural risk factors in a case-referent study of back disorders in an automobile assembly plant. The use of non-neutral trunk postures, such as forward flexion, lateral bending, and axial twisting, was associated with reports of back pain. The results of this study suggest that job redesign and/or other methods for controlling non-neutral posture be implemented to reduce the risk for back pain on industrial jobs. A general approach to work station design, based on a mechanical model of the human skeletal system is described. This model is used to develop specific job-design guidelines to prevent awkward trunk posture.

Klein, B.; Jensen, R.; Sanderson, L. Assessment of workers' compensation claims for back strains/sprains. *Journal of Occupational Medicine*. 1984; 26(6): 443-8.

Workers' compensation claim data for 1979 obtained from the Bureau of Labor Statistics' Supplementary Data System (SDS) were utilized to examine the demographic and occupational incidence of back strains/sprains among U.S.

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industrial employees covered by state compensation systems. These data were combined with estimated employment figures to provide incidence ratios, which allowed better approximations of industry- and occupation- specific risk. Industries found to have the largest incidence ratios were construction (1.6 claims/100 workers) and mining (1.5 claims/100 workers). Occupations with the largest ratios were miscellaneous laborers (12.3 claims/100 workers) and garbage collectors (11.1 claims/100 workers). The 285,468 compensation claims due to back strains/sprains filed in the 26 SDS states in 1979 suggest that back injuries continue to be a large and costly problem for U.S. workers and their employers.

Nelson, R.; Nestor, D. Standardized assessment of industrial low-back injuries: development of the NIOSH low-back atlas. *Topics in Acute Care and Trauma Rehabilitation*. 1988; 2(3): 16-30.

Note: NIOSH Abstract.

The research model used by the NIOSH Division of Safety Research in the development of the Low-Back Atlas (LBA) was described. According to the authors, low back injury is the leading musculoskeletal disorder in the United States and back injuries are the most frequent and costly musculoskeletal disorders. The development of the NIOSH LBA of standardized tests and measures was the first step at identifying risk factors for low back injuries and in the development of effective intervention strategies. The initial goal was to provide a reliable, standardized, clinical assessment for use by medical and industrial communities in assessing low back musculoskeletal injuries (LBMI). A list of performance criteria was developed to evaluate and provide a functional description of spinal movement dysfunction based on symptoms and signs. An expert panel of clinicians, researchers, and educators assembled a list of 105 tests procedures. A peer review panel accepted 85 tests and measures and recommended clinical evaluation. The evaluation task was done by grouping related areas into five categories which were then assigned to research sites at universities or clinical centers. The data on more than 250 LBMI patients were collected and analyzed. A final list of 68 acceptable and marginal tests and measures was assembled. Each test and measure was standardized and a clinical study was performed to evaluate the accepted procedures. On the basis of these trials a final list of 19 acceptable and marginal tests and measures was compiled, peer reviewed, and incorporated into the NIOSH LBA of standardized tests and measures.

Phillips, R.; Frymoyer, J.; MacPherson, B.; Newburg, A. Low back pain: a radiographic enigma. *Journal of Manipulative & Physiological Therapeutics*. 1986; 9(3): 183-87.

Ninety-nine anteroposterior and lateral lumbar radiographs taken of males ages 18-55 were independently analyzed by three chiropractors who assessed 56 variables, including determinations of disc space height, vertebral malalignments and spondylolistheses, spondylosis, postural disturbances, relationships between pelvis and spine, and other congenital or acquired abnormalities. The distribution of low back complaints in this study included 31% with no low back pain, 44% with previous or present mild low back pain and 24% with previous or current severe, and often disabling, low back pain. Determinations were made of interobserver reliability between the three chiropractors and a medical radiologist. Of the 56 radiographic variables assessed by the chiropractors, six demonstrated a high interobserver reliability. In general, the best reliability was for variables that were actual measurements, rather than subjective observations. Sixteen additional variables demonstrated a fair interobserver reliability. Comparison of

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the observations between a radiologist and the chiropractors showed correlations in their assessments of disc space height at L3-4 and L4-5; otherwise, there was poor interobserver reliability. Few of the radiographic variables were found to be reliable predictors of present or prior history of low back and leg complaints. A few variables (most notably disc space narrowing) were statistically associated with back or leg complaints ($P = 0.025$). We conclude that spinal radiographs, whether analyzed by measurements, by a radiologist or by chiropractors, have minimal value in predicting the presence or absence of low back complaints and, in particular, have no value in epidemiological studies.

Pope, M. Biomechanics of the lumbar spine. *Annals of Medicine*. 1989 Oct; 21(5): 347-51.

The magnitude of low back pain in terms of its occurrence and cost is reviewed. The biomechanics of the lumbar spine are related to the functional anatomy. The disparate functional mechanical requirements of the spine, support, mobility, housing, protection and control are reviewed. Typical forces one applies to the spine in activities of daily living as well as in mechanical overloads are discussed. The loads are broken down into tensile, compressive, shear and torsional loads. The posterior elements, the vertebral body and the intervertebral disc are reviewed separately and some implication in terms of the aetiology of low back pain is given. Finally, the behavior of the unit (the functional spinal unit) is discussed.

Pope, M. Risk indicators in low back pain. *Annals of Medicine*. 1989 Oct; 21(5): 387-92.

Injuries leading to low back pain can occur by direct trauma, overexertion or repetitive trauma. Overexertion is claimed by 60% of low back pain patients as the cause of injury. Of these patients with overexertion injuries, 66% implicated lifting and 20% pushing or pulling. It is, however, difficult to relate the workplace to the complaint of low back pain in a specific worker, and low back pain is found quite often in those with sedentary occupations. The incidence, severity and potential disability are all related to the demands on the individual in the workplace. Among the factors implicated are the requirements for lifting (particularly when compared to the worker's lifting capacity), pushing and pulling, posture, and cyclic loading. Drivers of heavy vehicles have two to four times the average incidence of serious low back pain. This is probably due to the cyclic loading environment. The general psychosocial environment (including that at work) is an important risk factor. The first attack of low back pain occurs in the teens or twenties. Low back pain is as frequent in females as males, although women in manual materials handling jobs are at greater risk. Posture, anthropometry and mobility measures have limited prognostic value. Muscle strength and physical fitness probably have some value. Radiographic findings have little pragmatic value.

Pope, M.; Rosen, J.; Wilder, D.; Frymoyer, J. The relation between biomechanical and psychological factors in patients with low-back pain. *Spine*. 1980; 5(2): 173-78. Behavioral factors are increasingly being recognized for their role in determining the course and outcome of low-back disorders. This paper examines the relation between behavioral variables, which include psychological symptoms and pain tolerance, and biomechanical variables. The majority of the 89 patients tested could be classified into two groups. One group was intolerant of pain and showed reduced spinal mobility, restricted straight leg raising, and altered flexor-extensor muscle balance. The other group was more tolerant of pain and did not show restriction of motion or muscle imbalance. Spinal mobility was also related to psychological symptoms. A model is proposed which points to a feedback

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between spinal motion and the patient's ability to cope with pain as one mechanism that determines return to a functional range of motion.

Reddell, C.; Congleton, J.; Huchingson, R.; Montgomery, J. An evaluation of a weightlifting belt and back injury prevention training class for airline baggage handlers. *Applied Ergonomics*. 1992; 23(5): 319-29.

This study evaluated the efficacy of a commercially available weightlifting belt in relation to reduction of lumbar injury incident rate and severity of injuries over an 8-month period. The study used 642 baggage handlers working for a major airline company as participants. Four treatment groups were randomly selected: a group receiving the belt only, a group receiving a 1 h training class only, a group receiving both a belt and a 1 h training class, and a control group receiving nothing. Two treatment groups were added which contained participants who discontinued use of the belt prior to the end of an 8-month study period. Results indicated that there were no significant differences for total lumbar injury incident rate, restricted workday case injury incident rate, lost workdays and restricted workdays rate, and worker's compensation rates. There was, however, a marginal significant difference for lost workday case injury incident rate. Groups with participants who wore the belt for a while then discontinued its use had a higher lost day case injury incident rate than did either the group receiving training only or the control group. Compliance was an overriding factor as the belt questionnaire response indicated that 58% of participants in the belt groups discontinued use of the belt before the end of 8 months. Comments made on the survey forms indicated that the belt was too hot. Similarly, comments suggested that the belt rubbed, pinched, and bruised ribs. Based on these results, the weightlifting belt used for this study cannot be recommended for use in aid of lifting during daily work activities of baggage handlers. Results indicate that use of the belts may, in fact, increase the risk of injury when not wearing a belt following a period of wearing a belt. As industries are experimenting with the use of belts, it is recommended that great care be taken in any further evaluation and close attention directed towards injuries which occur when not wearing the belt following a period of wearing the belt (i.e., off-the-job injuries).

Riihimaki, H. Low-back pain, its origin and risk indicators. *Scandinavian Journal of Work, Environment & Health*. 1991; 17(2): 81-90.

Low-back pain is a common ailment. Much is known of the pain-sensitive structures of the low back, but for a patient with acute low-back pain the cause can rarely be defined. Although the biochemical properties of the intervertebral discs and their degenerative changes have been unraveled, it is difficult to distinguish between pathological degeneration and normal changes due to aging. As a consequence of the problems in diagnosing back diseases, the most common measure of low-back morbidity in epidemiologic studies has been the occurrence of symptoms. A wide spectrum of work- and individual-related factors have been found to be associated with low-back pain, but little is known about the extent to which these factors are etiologic and the extent to which they are symptom-precipitating or symptom-aggravating.

Rossignol, M.; Suissa, S.; Abenhaim, L. Working disability due to occupational back pain: three-year follow-up of 2,300 compensated workers in Quebec. *Journal of Occupational Medicine*. 1988; 30(6): 502-05.

A cohort of 2,342 cases constituting a random sample of all occupational back injuries compensated in Quebec (Canada) during 1981 was observed prospectively for 3 years to study associations between cumulative duration of absence from work and sex, age, site of symptoms (cervical, thoracic, and

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lumbar), and occupation. Of the cohort members, 227 (9.7%) cumulated 6 months of absence or more. A logistic regression model showed age and site of symptoms to be the two most important risk factors associated with absences of 6 months or more. No association was found with sex or occupation. The results showed discrepancies between measures of frequency distribution of back injuries and duration of absence from work, an important finding in terms of identifying health priorities. [Mining and construction were the industrial sectors where length of absence for a back problem was found to be greatest. During the 3-year follow-up they experienced on average 151.2 and 120.8 days of absence from work, respectively (5.0 and 4.0 calendar months).].

Snook, S. Comparison of different approaches for the prevention of low back pain. *Applied Industrial Hygiene*. 1988; 3(3): 73-78.

Three major approaches have been used to reduce the problem of low back pain: training and education, job design (ergonomics), and job placement (selection). Training is the oldest and most common approach. Teaching the worker to lift with a straight back and bent knees is one of the oldest types of training found in industry. Unfortunately, it has been difficult to prove the effectiveness of this approach in reducing compensable low back pain. More effective results have come from training the worker in strength and physical fitness and in training management on how to respond to low back pain when it does occur. The training of practitioners in treating low back pain is also important since many long-term disability cases result from inappropriate treatment and/or the prolonged use of ineffective treatment. The ergonomic approach of designing the job to fit the capabilities of the worker has received greater attention in recent years. Unnecessary bending, twisting, and reaching are risk factors to be avoided in good job design. Criteria for determining excessive loads have been developed for use in evaluating and designing jobs. Studies have shown that good job design can reduce up to one-third of compensable low back pain. The use of ergonomic principles in job design can reduce the probability of initial and recurring episodes, allow the worker with moderate symptoms to stay on the job longer, and permit the disabled worker to return to the job sooner. The third approach to controlling low back pain is job placement, or selection of the worker to fit the job. This approach is particularly useful for jobs that are difficult to design or control such as firefighters, police, and certain construction and delivery operations. The use of medical criteria in job placement can identify up to 10 percent of young workers susceptible to low back pain. Studies on strength testing indicate that the probability of a musculoskeletal disorder is up to three times greater when job lifting requirements approach or exceed the worker's isometric strength capability. It is concluded that there is no simple solution to low back pain and that all three approaches are necessary for the best possible control of the disorder. However, some approaches are more effective than others and should be considered first in any program to reduce low back pain. Although knowledge about low back pain is limited, enough is already known to adequately control the problem. Instead of waiting for a major medical breakthrough to occur, emphasis should be placed on applying the knowledge that is already available.

Snook, S.; Jensen, R. Cost. M. Pope, J. Frymoyer, & G. Andersson (Eds.). *Occupational Low Back Pain*. New York: Praeger; 1984: 115-21.
Note: NIOSH Abstract.

Compensation costs for work related low back pain (LBP) were discussed. Estimates of compensation costs for LBP obtained from workers' compensation data were considered. A survey of nine states showed that back injuries

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averaged 21 percent of all compensable work injuries. Liberty Mutual Insurance Company, the largest underwriter of workers' compensation insurance in the United States, reported that in 1980 they paid 217,441,000 dollars for compensable back pain. Costs per case were discussed. The best estimates have shown that the mean cost of compensable back pain is around 6000 dollars per case. Distribution of back pain costs was discussed. A few high cost LBP cases accounted for most of the costs. For example, a study of 191 LBP cases in 1976 showed that 25 percent of the cases accounted for 90 percent of the cost. The high cost cases usually involved prolonged hospitalization, surgery, litigation, and psychological problems. Other costs associated with LBP were discussed. These included medical treatment and rehabilitation provided at a factory dispensary, wages paid to other workers during work time interrupted by the injury, wages paid to the supervisor while managing the incident, wages paid to the injured worker between the time of injury and the time when workers' compensation payments begin, cost for paying full wages to a replacement worker, and wages paid to clerks and others for preparing and processing compensation application forms.

Vanharanta, H.; Heliovaara, M.; Korpi, J.; Troup, J. Occupation, work load and the size and shape of lumbar vertebral canals. *Scandinavian Journal of Work, Environment & Health*. 1987; 13(2): 146-49.

Measurements made from plain lumbar radiographs were used to compare the size and shape of the lumbar vertebral canals between various categories of occupation and work load among 77 men and 118 women with a history of low-back pain. The mean anteroposterior foraminal diameters proved to be wider in female farm workers than in other women, especially in the vertebra L3 (17.1 versus 15.4 mm). However, the men who did heavy manual work had smaller anteroposterior foraminal diameters than the men whose work involved less physical labor (difference at L5 9.4 versus 10.8 mm). Female farm workers were found to have shorter interarticular distances than females in other occupational groups. In the men who reported working in stooped postures or reported lifting and carrying heavy objects at work, the interarticular distances were wider than in men who had no such exposures.

Webster, B.; Snook, S. The cost of compensable low back pain. *Journal of Occupational Medicine*. 1990; 32(1): 13-15.

Cost data were retrieved from all claims of low back pain initiated during 1986 (N = 98,999) from computerized records of the Liberty Mutual Insurance Company. The mean cost per case was \$6807; median cost, \$391. Medical costs represented 31.5% of the total costs; indemnity costs, 67.2%. The total compensable cost for all low back pain in the United States was estimated to be \$11.1 billion. Large variations were found to exist among different states in cost per case and percentage of costs for indemnity and medical payments.

Wickstrom, G. Effect of work on degenerative back disease. A review. *Scandinavian Journal of Work, Environment & Health*. 1978; 4(Suppl 1): 1-12.

Note: NIOSH Abstract.

Work effects on degenerative back disease were discussed. Symptoms derived from lumbar degeneration are stiffness, ache, and sharp and radiating pain, and other signs that can be detected radiologically. According to the authors, heredity may be important, but its effects were observed to be surpassed by the mechanical stress of hard physical work. The occurrence of degenerative back disease in an number of different occupations, particularly miners and foundry workers, was discussed. Occupational factors causing back strain include injury,

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heavy lifting and carrying, posture, whole body vibration, and climate.

Wickstrom, G.; Pentti, J.; Hyytinen, K. Type A behaviour and back pain. *Work and Stress*. 1989; 3(2): 203-07.

Note: NIOSH Abstract.

The potential relation between back pain and competitiveness, in the form of type-A behavior, was examined in this intervention study aimed at reducing the occurrence of back pain. Four hundred and sixty one male workers representing five different occupations in the metal industry (work planners, planners, sheet metal workers, welders, and plumbers) responded to a questionnaire on competitiveness as a personality dimension and experience of back pain. Competitive behavior was found to be twice as common among sedentary employees than among manual workers. Experience of back pain radiating to a leg was more common in the manual workers with a competitive personality than in the noncompetitive ones; this relationship was not observed in sedentary employees. The authors suggest that this finding could be due to a more common occurrence of over exertion and trauma affecting the back tissues in competitive type-A workers; such workers would be more prone to use all their strength than the less competitive type-B workers, thereby predisposing them to musculoskeletal trauma. The authors propose that in the population at large, more attention should be given to leisure time activities; as for manual workers, health education on the risks of back injury should be improved parallel to attempts to reduce peak loads.

Wilder, D.; Pope, M.; Frymoyer, J. The biomechanics of lumbar disc herniation and the effect of overload and instability. *Journal of Spinal Disorders*. 1988; 1(1): 16-32.

A multipart study has been performed to provide a mechanical explanation for the epidemiologic association between sitting in static (e.g., factory or office) or vibration (e.g., car or truck driving) environments and acute herniated lumbar discs. It was shown that a 1 h exposure to sitting environments caused significant changes in the mechanical properties of the lumbar intervertebral disc. During many of the latter tests, specimens were unstable (exhibited by a sudden, large flexion and/or lateral bend rotation response to an axially applied load). This showed that a motion segment in the lumbar spine could suddenly buckle and apply a tensile impact loading to the posterolateral region of the disc. We also demonstrated that a combined lateral bend, flexion, and axial rotation vibration loading could cause tracking tears proceeding from the nucleus through the posterolateral region of the annulus. It suggests that a mechanism for disc herniation is mechanical changes leading to instability of the motion segment. These experiments complete the argument that lumbar disc herniations can be a direct mechanical consequence of prolonged sitting in static or vibration environments.

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Bjorklund, M.; Helmerskog, P.; Nordberg-Bohlin, M.; Soderman, U.; Holmqvist, L.; Lindblad, B.; Makynen, J.; Ahrman, S. 90-sheets for the 90s. *Bygghalsan Bulletin*. 1991-09-16.

Note: English Abstract.

An abstract of an ergonomic analysis of using 90 cm wide drywall boards. Handling sheets of plasterboard is a well documented area within the construction industry and the authors state that current working methods often

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load the workers wrongly. Surveys, carried out using biomechanical calculations, load analysis in accordance with NIOSH and entire body load analysis in accordance with ARBAN, all show the advantages of using 90 cm boards. The summarized opinion of the board fitters responding to a questionnaire was that the work was easier with 90 cm boards and that their working situation had improved.

Chaffin, D. Manual materials handling and the biomechanical basis for prevention of low-back pain in industry--an overview. *American Industrial Hygiene Association Journal*. 1987; 48(12): 989-96.

Two different but dependent strategies must be developed to prevent low-back pain in industry. One is of an administrative nature and is concerned with whether the worker who performs activities that stress back tissues is appropriately evaluated and trained for such work. The second strategy is of an engineering type, dealing with methods to assure that the workplace and work tasks are specified in ways that minimize injurious stresses to the low back. Both of these strategies rely on knowledge of the biomechanical requirements of a job. These must be carefully evaluated by informed observers using prescribed measurement and analysis procedures. The fundamental biomechanics of heavy lifting and observational procedures developed by an expert panel for NIOSH are described. The procedure rates the difficulty of a lifting task and then recommends whether administrative or engineering controls are warranted to reduce low-back stresses. Some suggestions for preventing excessive low-back stress by redesigning the workplace are presented also.

Ciriello, V.; Snook, S.; Blick, A.; Wilkinson, P. The effects of task duration on psychophysically-determined maximum acceptable weights and forces. *Ergonomics*. 1990; 33(2): 187-200.

The purpose of this experiment was to investigate maximum acceptable weights and forces when performing manual handling tasks continuously for four hours at frequencies of 4.3 min⁻¹ or slower. Twelve female and ten male second shift industrial workers performed 18 varieties of lifting, lowering, pushing, pulling, and carrying. A psychophysical methodology was employed, whereby the subjects were asked to select a workload they could sustain for 8 h 'without straining themselves or without becoming unusually tired, weakened, overheated or out of breath'. Measurements of heart rate, oxygen consumption, dynamic and static strengths were also taken. The weights selected after 40 min were not significantly different from the weights selected after four hours. The average oxygen consumption for the fast tasks was 28% VO₂ max, within physiological guidelines for eight hours. The results also revealed that the maximum acceptable weights for the combination task of lifting, carrying, and lowering were limited by the lifting and lowering components. It is concluded from the results of this study that the psychophysical methodology is appropriate for determining maximum acceptable weights for task frequencies of 4.3 min⁻¹ or slower. It is also concluded that the maximum acceptable weight for a combination task is limited by the lowest acceptable weight of any of the components.

Construction Safety Association of Ontario and Bygghalsan of Sweden.

Stand/Lift/Carry. Toronto, Ontario: Construction Safety Association of Ontario; 1986.

A guide to proper lifting and carrying practices for the construction industry. Construction today still involves work that puts physical stress on the body. Various studies have shown that the construction trades have a higher incidence of locomotory disorders than many other occupations. A Swedish study of

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construction apprentices found that 18% had back problems when they began their training. This figure rose to 40% by the end of the second year. Pain in the back and joints is a predominant factor in forced retirement from the construction trades and in workers seeking less demanding occupations. Such changes are often accompanied by a serious reduction in living standard. In Canada as in Sweden, nearly 25% of the lost-time injuries in construction have their origin in the back. Indeed, it is estimated that 80% of the population will experience low back pain at some point in their working lives. In construction, about half of the back injuries result from lifting excessive weights or lifting incorrectly while roughly 23% are the result of slips, trips or falls.

Erneling, L. Easy-to-handle packagings at building sites. *Bygghalsan Bulletin*. 1983-05-01.

Note: English Abstract.

An abstract on packaging redesign for building materials. The package design recommendations are considered under three categories: shape, material, and size. Some of the suggestions include putting handles on putty bags and using oval and rectangular paint tins, instead of the round tins in common use.

Freivalds, A. Comparison of United States (NIOSH Lifting Guidelines) and European (ECSC Force Limits) recommendations for manual work limits. *American Industrial Hygiene Association Journal*. 1987; 48(8): 698-702.

In the early 1980's two different guidelines for manual lifting were established: the NIOSH Work Practices Guide for Manual Lifting and the European Coal and Steel Community's Force Limits in Manual Work. A comparison of the two guidelines indicates some discrepancies in their predictive capabilities and a significant nonlinear relationship between the two limits. These discrepancies may be explained by differences in respective predictive equations, assumptions and underlying concepts.

Freivalds, A.; Chaffin, D.; Garg, A.; Lee, K. A dynamic biomechanical evaluation of lifting maximum acceptable loads. *Journal of Biomechanics*. 1984; 17(4): 251-62. A biomechanical evaluation of the job-related stresses imposed upon a worker is a potential means of reducing the high incidence rates of manual material handling injuries in industry. A biomechanical model consisting of seven rigid links joined at six articulations has been developed for this purpose. Using data from cinematographic analysis of lifting motions the model calculates: (1) body position from articulation angles, (2) angular velocities and accelerations, (3) inertial moments and forces, and (4) reactive moments and forces at each articulation, including the L5/S1 joint. Results indicated effects of the common task variables. Larger load and box sizes increased the rise times and peak values of both vertical ground reaction forces and predicted L5/S1 compressive forces. However, boxes with handles resulted in higher L5/S1 compressive forces than for boxes without handles. Also, in lifting the larger boxes the subjects did not sufficiently compensate with reduced box weights in order to maintain uniform L5/S1 compressive forces. Smoothed and rectified EMG of erector spinae muscles correlated significantly with L5/S1 compressive forces, while predicted and measured vertical ground reaction forces also correlated significantly, indicating the validity of the model as a tool for predicting job physical stresses.

Genaidy, A.; Asfour, S. Effects of frequency and load to lift on endurance time.

Ergonomics. 1989 Jan; 32(1): 51-57.

The purpose of the present study was to determine endurance time for manual lifting tasks which were performed over a wide range of loads (5, 10, 15, and 20

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kg) and frequencies (4, 6, 8, and 10 times/min) for a lift from floor to table height. Endurance time was defined in this study as the maximum length of time during which an individual was capable of lifting a given load at a given frequency continuously. The upper limit of endurance time was set to 8 h. Eleven male subjects participated in this study, and the lifting technique utilized with the straight back-bent knees method. The results showed that endurance time was significantly reduced with an increase in frequency or load of lift. The lightest frequency-load combination (4 times/min; 5 kg) was maintained by most of the subjects for 8 h. Conversely, the average endurance time for the heaviest frequency-load combination (10 times/min; 20 kg) was about 27 minutes.

Genaidy, A.; Bafna, K.; Sarmidy, R.; Sana, P. A muscular endurance training program for symmetrical and asymmetrical manual lifting tasks. *Journal of Occupational Medicine*. 1990; 32(3): 226-33.

The purpose of this study was to test whether the endurance limits of new employees engaged in symmetrical and asymmetrical manual lifting tasks can be significantly increased through a physical training program. Each subject participating in the training program performed a total of 16 sessions. A control group performed two sessions separated by a 4-week interval. The results of this study showed that endurance time increased by 248% for the symmetrical and 46% for the asymmetrical lifting tasks. Furthermore, the frequency of handling increased by 44% and 34% for these tasks, respectively. The control group showed no improvement in terms of endurance time and frequency of handling. The implementation of a physical training program as a tool to control overexertion injuries in industrial settings is outlined.

International Labour Office. *Maximum Weights in Load Lifting and Carrying*. Geneva, Switzerland: International Labour Office; 1988.

Note: Occupational Safety and Health Series No. 59.

A summary of the legislation and practice concerning the limitations of weight in manual lifting and carrying of loads adopted in various ILO member States.

Keyserling, W. Analysis of manual lifting tasks: a qualitative alternative to the NIOSH work practices guide. *American Industrial Hygiene Association Journal*. 1989; 50(3): 165-73.

A new method for evaluating ergonomic stresses on lifting tasks has been developed. This method utilizes the general procedures and hazard classification categories described in the National Institute for Occupational Safety and Health's (NIOSH) Work Practices Guide for Manual Lifting. The quantitative measurements of workplace dimensions and computations used by the NIOSH method to classify a job as "acceptable," "administrative controls required," or "hazardous" have been eliminated in favor of a table look-up procedure. A computer simulation was performed to compare results generated by the new method to results generated by the NIOSH method. The results of this simulation found that the new method was unbiased and was reasonably precise for most lifting activities.

Koningsveld, E. Permissible loads for the Dutch construction industry. *Ergonomics*. 1985; 28(1): 359-63.

The Foundation for Occupational Health Care in the Dutch Construction Industry has developed a research programme and a health campaign in order to prevent low-back pain. One of the activities was the development of directives for permissible loads for manual handling. On the basis of a study of the literature and of the legal requirements of several countries, we have tried to draw up such

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directives on behalf of the construction industry. We came to the conclusion that there is no scientific basis for a regulation that has such a solid basis that it can be forcefully advised, or even obliged. Nevertheless we have drawn up tentative directives, that can be adjusted when scientific progress gives reason to do so.

List, E.; Wallenquist, A. Aids for the partially disabled: devices for interior installation work. *Bygghalsan Bulletin*. 1977-05-01.

Note: English Abstract.

An abstract of a study evaluating aids and lifting devices that would enable elderly workers in the building trade, who, as a result of pain in the shoulder-girdle, neck or back find it increasingly difficult to do their work, to continue working with the help of suitable aids.

Mittal, M.; Malik, S. Biomechanical evaluation of lift postures in adult Koli female labourers. *Ergonomics*. 1991; 34(1): 103-8.

Three lift-postures, back straight and knees bent, back bent and knees straight and squatting were evaluated biomechanically based on data from 100 Koli female labourers, when lifting loads from the floor to hold them at knee height. The maximum weight was lifted with the back bent and the knees straight which is a posture commonly used by Indian labourers for lifting a load. Squatting (a posture used by Indians for performing household chores) produced the least physical strain in terms of moment and moment ratio (moment per kilogramme of load lifted). Consequently, squatting was found to be the best posture for lifting a load, specifically for the Indian labourers who are accustomed to squatting when working.

Mittal, M.; Malik, S. Subjective assessment of lift postures in adult Koli females working at construction sites. *International Journal of Industrial Ergonomics*. 1991; 7(1): 25-29.

Three lift postures of straight back, bent back and squatting were evaluated by obtaining subject's opinion on the site, intensity and frequency of pain after holding the maximum load for one and two minutes. The study was based on a sample of 100 adult Koli female labourers. Most of the subjects reported knee pain in straight back posture, pain in the lower part of the back in the bent back posture, and pain in the lower arm in the squatting posture. In the majority of the subjects, the site of pain remained unchanged for one minute and two minutes of weight holding. Since the intensity and the frequency of pain after holding the load for one and two minutes were the least in the straight back and squatting postures, they were judged to be the best postures for repetitive and continuous holding tasks, respectively. Adoption of proper posture is a must for lifting load in industries and work situations requiring manual work. Inter-postural comparisons reveal that squatting posture is a better choice for lifting load, specially in Indian labourers who are accustomed to squat.

NIOSH. Work Practices Guide for Manual Lifting. DHHS (NIOSH) Publication, Cincinnati, Ohio Technical Report No. 81-122. 1981; 183 pages.

Note: NIOSH Abstract.

Research on the hazards of manual materials handling in industry is summarized and recommendations to reduce the human and economic burden imposed by improper materials handling are provided. Epidemiological, biomechanical, physiological, and psychophysical criteria are discussed for establishing work practice guidelines. Recommendations regarding the safe load weight, size, location and frequency of handling are presented along with mitigating factors such as worker training and physical fitness. Worker training and selection criteria

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are listed, and engineering guidelines are provided for the design of workplaces where manual materials handling is performed. [NIOSH is publishing the recent revision of these guidelines in a forthcoming issue of the journal *Ergonomics*.]

Niskanen, T.; Lauttalammi, J. Accidents in materials handling at building construction sites. *Journal of Occupational Accidents*. 1989; 11(1): 1-17.

Note: NIOSH Abstract.

Factors influencing the occurrence of accidents in materials and structural elements handling were analyzed. Materials and structural elements handling included transporting, lifting and carrying at the construction site, storage at the worksite, the assembly and stripping of formwork, the erection of structural units, and other activities. All accident notification forms pertaining to accidents involving materials handling that had occurred in one large construction company in Finland over a 5 year period were collected for a total of 442 forms. Each of the 442 accident reports was classified according to the construction phase, the work operation, the event causing the injury, the activity at the moment of the accident, the object causing injury, the part of the body injured in the accident, the type of injury, the period of disability, the accident compensation costs paid by the insurance company, and the occupation. Of the total number of injuries, 5.5% were fractures, 19.1% were contusions, and 55.1% were sprains and strains. About 28% involved injuries to the back. The greatest risk was present during the construction of frame structures. Circumstances frequently preceding serious accidents included delayed or incomplete delivery of materials to the work site and inadequate or misunderstood communication by signs. The high number of board handling accidents found indicated that preventive measures must be developed. Of the materials handling accidents, 64% occurred during manual lifting and carrying, whereas overexertion of work movement caused 36% of the accidents. Transported or lifted materials were involved in 52% of the accidents with the most hazardous activities in this category being the handling of building boards, doors and windows, timber, and of products packed in sacks. Overexerting work movement was involved in 35.7% of the accidents with manual lifting causes accounting for 39% of these, manual carrying 36%, pulling 6%, and pushing 8%.

Parnianpour, M.; Campello, M.; Sheikhzadeh, A. The effect of posture on triaxial trunk strength in different directions: its biomechanical consideration with respect to incidence of low-back problem in construction industry. *International Journal of Industrial Ergonomics*. 1991; 8(3): 279-87.

There has been no previous study investigating the triaxial strength potentials of the trunk muscles in a pre-rotated spine. A great many lifting tasks in the construction industry occur while the trunk has already been flexed in the sagittal plane. The purpose of this study was (a) to measure the triaxial maximum isometric strength of normal male subjects in all six possible directions while standing in three different postures: 0, 20, and 36 degrees of trunk flexion; (b) to assess the effect of posture on the maximum isometric torque in all six directions. The highest maximum isometric extension and flexion torques were recorded at 36 degrees of trunk flexion - they increased by 68% and 36% with respect to upright posture. The flexion angle significantly affected the measured torques in the intended plane of exertion during attempted flexion and extension, while the torques in the accessory planes were affected in the attempted right and left lateral bending and axial rotation ($p < 0.05$). The results of this study conflict with the recommended lifting technique: Lift with a straight back and bent knees. The development of a triaxial trunk muscle functional capacity database is initiated.

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Pizatella, T.; Putz-Anderson, V.; Bobick, T.; McGlothlin, J.; Waters, T. Understanding and evaluating manual handling injuries: NIOSH research studies. *Ergonomics*. 1992; 35(9): 945-53.

This paper presents an overview of NIOSH research aimed at characterizing and identifying intervention strategies for reducing musculoskeletal injuries during manual handling activities. Surveillance and evaluative research projects are reviewed. Future research directions of the Institute are also discussed.

Snook, S.; Ciriello, V. The design of manual handling tasks: revised tables of maximum acceptable weights and forces. *Ergonomics*. 1991; 34(9): 1197-213.

Four new manual handling experiments are reviewed. The experiment used male and female subjects to study lifting, lowering, pushing, pulling, and carrying tasks. Each experiment used a psychophysical methodology with measurements of oxygen consumption, heart rate, and anthropometric characteristics. Independent variables included task frequency, distance, height and duration; object size and handles; extended horizontal reach; and combination tasks. The results of the four experiments were integrated with the results of seven similar experiments published previously by this laboratory. The integrated data were used to revise maximum acceptable weights and forces originally published in 1978. The revised tables are presented and compared with the original tables.

Stubbs, D. Trunk stresses in construction and other industrial workers. *Spine*. 1981; 6(1): 83-89.

One of the problems arising from the consideration of safety during manual handling in industry has been, firstly, a definition of those workers at risk and, secondly, a definition of safety. To be able objectively to identify those at risk and quantify the stress to which they are exposed, a more rigorous series of criteria is required if prevention of back pain in industry is to be achieved. This paper concerns such a methodology which allows the quantification of truncal stresses to which identifiable high-risk industrial groups are exposed. The methodology is described using three industrial examples of populations who suffer considerable back hazard from their occupations. In the examples given, both direct measurements of truncal stresses will be presented together with contour applications whereby the safety of a handling task can be assessed by reference to diagrams.

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Armstrong, T.; Buckle, P.; Fine, L.; Hagberg, M.; Jonsson, B.; Kilbom, A.; Kuorinka, I.; Silverstein, B.; Sjogaard, G.; Viikari-Juntura, E. A conceptual model for work-related neck and upper-limb musculoskeletal disorders. *Scand J Work Environ Health*. 1993; 19: 73-84.

This paper presents a conceptual model for the pathogenesis of work-related musculoskeletal disorders. The model contains sets of cascading exposure, dose, capacity, and response variables, such that response at one level can act as dose at the next. Response to one or more doses can diminish or increase the capacity for responding to successive doses. The model is used as a framework for discussing the development of work-related muscle, tendon, and nerve disorders. It is intended as a beginning, to be modified to explain new findings as they become available. In research, it can help to identify areas needing additional data for the development and expression of work-related musculoskeletal disorders. Researchers can use it to design laboratory and field

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studies. In practice, it demonstrates the relationship between common exposure factors and different responses. This information can be used to evaluate and design jobs for the prevention of work-related musculoskeletal disorders.

Beimborn, D.; Morrissey, M. A review of the literature related to trunk muscle performance. *Spine*. 1988; 13(6): 655-60.

In the past, there has been no comprehensive review of the literature pertaining to different methods of assessing trunk muscle strength. This review describes the different studies that have been performed, and determines the hierarchy of strength values and agonist/antagonist strength ratios for the trunk musculature. In general, the strength hierarchy consists of, from strongest to weakest: extension, flexion, side bending, and rotation. The agonist/antagonist ratio for extension/flexion is 1.30 and for rotation and side bending, motion to the right approximately equals motion to the left. Changes in the relative strengths of the different trunk muscle groups is affected by spinal pathology, and this is discussed. Possible clinical implications and direction for future research are delineated based on the findings of this review.

Borg, G. Psychophysical scaling with applications in physical work and the perception of exertion. *Scandinavian Journal of Work, Environment & Health*. 1990; 16 (Suppl)1:55-58.

In studies on work it is important to assess various subjective symptoms, complaints, and annoyances. To measure such symptoms, psychophysical ratio scales may be used, as along with simpler category rating scales. In this paper some of the basic concepts and methods of psychophysics have been described. In the field of heavy physical work and the perception of effort and exertion, one of the most popular methods is the rating of perceived exertion. This scale has been presented together with a new category ratio scale, commonly referred to as the CR-10 scale. Some situations in which it is important to obtain measurements of perceived exertion have also been described in the paper.

Carlsoo, S.; Hammarskjold, E. Postures and loads: a guide to strain in different body positions. *Bygghalsan Bulletin*. 1987- 05-01.

Note: English Abstract.

Body postures and movements, as well as the interaction between underlying forces, are matters of central importance in all ergonomic assessments. This guide attempts to illustrate, describe and evaluate the amount of strain on the human body in different positions.

Eklund, J.; Corlett, E. Shrinkage as a measure of the effect of load on the spine. *Spine*. 1984; 9(2): 189-94.

A new method for measuring spinal load is proposed, whereby changes in body height are used as a measure of disc compression. The rate and magnitude of disc compression are caused by the loading and its temporal pattern. A device is reported for measuring body height (SD less than 1 mm). Experiments showed the diurnal shrinkage during a working day and the rapid recovery when lying down. Other experiments demonstrated how the rate of shrinkage is a function of the load on the spine. Further, shrinkage when sitting in different chairs has been compared, and the results are in agreement with disc pressure measurements, reported in the literature. Finally, examples are given of how the method can be used in ergonomic evaluations.

Holzmann-Voigt, P. ARBAN: a method for ergonomic analysis of work sites. *Arh Hig Rada Toksikol*. 1979; 30(Suppl): 1207-09.

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A method for analysing ergonomic conditions of work sites is described. The method is based on continuous video-records of work sites, analysed in a laboratory. There, the tape is stopped and the TV-picture is "frozen" at short intervals. The postures of different parts of the worker's body in the stop moment are observed separately. The stress due to the body posture as well as the influence of isometric muscle contraction and external forces are taken into consideration. All factors are then weighed together and the instant stress of every part of the body as well as the total stress is calculated. If there are peak rates of any part or if the total stress of the body exceeds a certain previously stipulated value, the TV screen is pictured. After the analysis of the whole video tape the distribution of the loads is analysed statistically. The results of this analysis show the stress of the different parts of the body during the observed period and its variation with time. The analysis also makes it possible to determine if the loads are mainly caused by rear heavy loads, frequently recurring moderate ones or by a bad working posture. It also allows an estimation of the total ergonomic situation, and comparison with the situations at other work sites. The pictures and the statistical analysis together form a basis for developing work facilities.

Holzmann, P. ARBAN: a new method for analysis of ergonomic effort. *Applied Ergonomics*. 1982; (June): 82-86.

ARBAN is a method for the ergonomic analysis of work, including work situations which involve widely differing body postures and loads. The idea of the method is that all phases of the analysis process that imply specific knowledge on ergonomics are taken over by filming equipment and a computer routine. All tasks that must be carried out by the investigator in the process of analysis are so designed that they appear as evident by the use of systematic common sense. The ARBAN analysis method contains four steps: (1) Recording of the workplace situation on video or film. (2) Coding the posture and load situation at a number of closely spaced 'frozen' situations. (3) Computerization. (4) Evaluation of the results. The computer calculates figures for the total ergonomic stress on the whole body as well as on different parts of the body separately. They are presented as 'Ergonomic stress/time curves', where the heavy load situations occur as peaks of the curve. The work cycle may also be divided into different tasks, where the stress and duration patterns can be compared. The integral of the curves are calculated for single-figure comparison of different tasks as well as different work situations.

Hsiao, H.; Keyserling, W. A three-dimensional ultrasonic system for posture measurement. *Ergonomics*. 1990; 33(9): 1089-114.

A time-efficient, cost-effective, and accurate system has been developed for measuring static three-dimensional joint coordinates in the laboratory. This system uses a personal computer interface to determine the distance between transmitters positioned at body joints and receivers positioned near the subject by measuring the travel time of ultrasound. Distance data are then converted to spatial coordinates and joint angles. The system can determine the location of 14 joints at one time. An experiment using three distances and five orientations between a transmitter and a receiver was performed to investigate the significance of measurement errors for the new system. The results showed that the standard deviation of the distance measurement was about 0.2 cm for single orientation conditions and was about 1 cm for all conditions tested. A second experiment using 11 transmitters and four receivers was performed to investigate the significance of measurement errors when determining three-dimensional coordinates. The results showed no significant difference between actual and

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measured coordinates. The system was then used to study the posture of a subject's upper extremity. Eight postures representing a variety of typical reaching tasks were examined. The results showed that the system was suitable for three-dimensional posture measurement.

Keyserling, W. A computer-aided system to evaluate postural stress in the workplace. *American Industrial Hygiene Association Journal*. 1986; 47(10): 641-49.
Stress caused by awkward working posture of the trunk and shoulders can result in fatigue, musculoskeletal disorders and nerve entrapment syndromes. To aid in evaluating the relationship between work activities and postural stress, a computer-aided system was developed. This system produces a detailed description of work tasks and a continuous record of trunk and shoulder activity on the same time scale. The system was used to evaluate postural stresses on a case study job in an automobile assembly plant. The results of the postural analysis were used to identify specific causes of postural stress and to develop recommendations for changes in work station equipment and methods to reduce stress.

Keyserling, W.; Punnett, L.; Fine, L. Trunk posture and back pain: identification and control of occupational risk factors. *Applied Industrial Hygiene*. 1988; 3(3): 87-92.
Awkward trunk posture during work can be caused by a number of controllable factors, including poor work station layout, inappropriate design of tools and equipment, and/or incorrect work methods. If not eliminated, these postures can cause fatigue and contribute to the development of pain and disorders in the lower back. A computer-aided system was developed to evaluate trunk posture during work by measuring the time spent in neutral and non-neutral postures. This system was used to assess postural risk factors in a case-referent study of back disorders in an automobile assembly plant. The use of non-neutral trunk postures, such as forward flexion, lateral bending, and axial twisting, was associated with reports of back pain. The results of this study suggest that job redesign and/or other methods for controlling non-neutral posture be implemented to reduce the risk for back pain on industrial jobs. A general approach to work station design, based on a mechanical model of the human skeletal system is described. This model is used to develop specific job-design guidelines to prevent awkward trunk posture.

Long, A. A computerized system for OWAS field collection and analysis. M. Mattila & W. Karwowski (Eds.). *Computer Applications in Ergonomics, Occupational Safety and Health*. Amsterdam: Elsevier Science Publishers, B.V.; 1992: 353-58.
The Ovako Working posture Analysing System (OWAS) is a useful tool in the examination of working postures. However, data collection and analysis can be a tedious process. This paper describes a collection and analysis software package that allows data to be collected and analysed efficiently in the workplace. The OWAS posture code and work phase of each observation is recorded. A work phase is a task within a job, e.g. patient showering within nursing. The collection program prompts for OWAS posture codes and work phase at a time interval specified by the observer. The full range of OWAS codes are permanently displayed, making the program easy to use. The analysis program analyses the data according to action category, work phase or body segment (back, arms and legs) and effort exerted. This package was designed to run on a basic laptop or notebook computer, but it can be used on any computer (MS-DOS based). The use of a laptop computer allows the data to be easily collected in the field with minimal interference in the workplace. The only equipment required to run this package is a laptop computer which is commonly available in industry. Thus, this

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software offers efficient OWAS collection and analysis for researchers and workplace-based occupational health and safety personnel with some training. This system has been used successfully, along with other field methods, in a back intervention study.

Long, A.; Louhevaara, V. Computerized collection and analysis of minute by minute physical activity and work phase data. M. Mattila & W. Karwowski (Ed.). *Computer Applications in Ergonomics, Occupational Safety and Health*. Amsterdam: Elsevier Science Publishers B.V.; 1992: 445-51.

This paper describes a software package that allows the collection and analysis of physical activity levels and work phase data in the field. The present physical activity levels are based on the Edholm scale but modified for manual materials handling jobs. The quality and quantity of muscular work activity is briefly described at each level of the scale which also provides a rough guide to energy expenditure and metabolic rate. A work phase is a task within a job, e.g. patient showering within nursing. The package consists of two distinct programs: collection and analysis. The programs have been designed to be used on a basic laptop, or notebook computer, but they can be run on any MS-DOS based computer. The use of a laptop computer allows the data to be easily collected in the field with minimal impact on the work. The only specialized equipment needed is a laptop, or notebook computer, these are readily available, versatile and inexpensive. The package has been designed so that all the information necessary to use the programs is available from the software, although manuals are provided. In the collection program the observer is automatically prompted to enter physical activity level and work phase information every minute. The codes are provided as a screen display for easy reference. The display at any one time represents one hour with any previous hour being able to be recalled. The analysis program produces a table which is a summary, in minutes and percentage of total time, of time spent at particular physical activity level and work phase. The table allows the observer to determine the time spent: in a particular work phase; at a specific activity level; or at a specific activity level for a particular work phase. This system has been used successfully, along with other tools, in a back load intervention study in which workload on the back was reduced in different manual handling jobs.

Moore, A.; Wells, R.; Ranney, D. Quantifying exposure in occupational manual tasks with cumulative trauma disorder potential. *Ergonomics*. 1991; 34(12): 1433-53. A method of describing the musculoskeletal loads in the hand and wrist during manual tasks is presented. A profile of twelve factors is used to quantify the exposure of applicable soft tissues to modes of loading suggested as being related to a number of chronic, work-related musculoskeletal disorders such as chronic muscle strain, tenosynovitis, and carpal tunnel syndrome. These factors include estimates of tendon loads and movement, frictional work done on the tendon sheaths, and muscle activation determined using electromyography. The response of these measures to changes of force, repetition, and posture was studied using eight conditions of a simulated task utilizing a pistol grip tool. Measures of tendon frictional work and dynamic electromyographic activity best paralleled the injury outcomes of an epidemiological study using similar task definitions (Silverstein et al. 1986). This field-usable system is being used currently to investigate the relationship between occupational exposure and musculoskeletal disorders.

Radwin, R.; Lin, M. An analytical method for characterizing repetitive motion and postural stress using spectral analysis. *Ergonomics*. 1993; 36(4): 379-89.

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The availability of small, inexpensive electrogoniometers has made wrist posture measurement during repetitive manual work practical. Efficient analytical methods, however, are not currently available for quantifying the degree of repetitiveness and the interaction with postural stress. Spectral analysis was investigated as a method for characterizing repetitive wrist motion and postural stress using a simple peg transfer task. Wrist posture was controlled by adjusting the pegboard location and by having subjects reach over an obstruction. Work pace was externally controlled using an auditory signal. Angular wrist flexion/extension and ulnar/radial deviation was recorded using a 60 Hz sample rate. Power spectra were computed by stratifying data segments into individual work elements, divided by break points associated with the task. Peak spectral magnitudes and frequency components corresponded closely with joint displacement amplitudes and repetition rates. Spectrum DC component magnitudes were directly related to sustained wrist postures.

Samuelson, B.; Wangenheim, M.; Wos, H. A device for three-dimensional registration of human movement. *Ergonomics*. 1987; 30: 1655-70.

A device for three-dimensional registration of human movement was tested. For this, a special garment with 43 attached light-emitting diodes was developed. The garment was specially designed for biomechanical purposes and made of a highly elastic material in the form of an overall. A recording system working with infra-red light was also tested considering both technical aspects and software. Test recordings of predetermined body movements within a defined work area of over 10 m² showed that the device satisfies general practical requirements. The garment worked very well for different movements and for bodies of different shapes and sizes. Technically the system was tested with respect to noise and linearity, operating function, range and manageability. It worked well with some limitations such as reflections. The tested software functions, such as recording speed, processing time, interpolation and user compatibility, proved to fulfil their main needs.

Stetson, D.; Keyserling, W.; Silverstein, B.; Leonard, J. Observational analysis of the hand and wrist: a pilot study. *Applied Occupational & Environmental Hygiene*. 1991; 6(11): 927-37.

A system for quantitative analysis of risk factors associated with cumulative trauma disorders of the hand and wrist was developed and tested in a pilot study. To use the system, analysts observed the worker and counted the total number of hand exertions per work cycle and the number of exertions associated with specific risk factors such as high force or adverse postures. Pilot study analyses were performed both at the job site and from videotapes of the jobs. Analyses of hand posture performed at the job site provided more accurate data than did analyses performed from videotapes. Compared to analysis methods that utilize frame-by-frame review of videotape or film, the proposed system required considerably less time. Agreement among analysts was strong. The system may be used for quantitative descriptions of ergonomic risk factors on hand-intensive jobs, pre- and postintervention comparisons of engineering and administrative controls, and exposure classification in epidemiologic studies of work-related, soft tissue disorders of the hand and wrist.

Vayrynen, S. The computer as an aid in the analysis of ergonomic and safety features of maintenance. Description of two graphic applications. *Scandinavian Journal of Work, Environment & Health*. 1988; 14(Suppl 1): 105-07.

Note: NIOSH Abstract.

Computer aided design systems for ergonomic and safety analysis of equipment

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maintenance tasks were discussed. A program called MINTAC created a three dimensional graphic model of a man which could be modified and placed in a three dimensional work environment model. There were six links in the man model, and man machine interactions could be evaluated by several biomechanical and environmental parameters. It was noted that limitations in accessibility were the cause of forced postures in maintenance work. A Finnish method named the Ovako working posture analyzing system was used in analysis of maintenance of forest tractors. This program was designed for use on a large computer aided design system. A second application was the Ovako working posture analyzing system, computer aided, which was intended to show and rank work postures in heavy mobile manual tasks. This program was easy to learn and could be used on personal microcomputers. The author concludes that this software, along with an increase in microcomputer use by health and safety professionals, allows for the redesign of work spaces and work methods for decreasing postural load and that it can be integrated into computer aided design packages for actual ergonomic design purposes. Such systems provide designers with qualitative and quantitative answers to questions which previously were answerable only by intuition and experience.

- Vink, P.; Daanen, H.; Meijst, W.; Ligteringen, J. Decrease in back strength in asymmetric trunk postures. *Ergonomics*. 1992; 35(4): 405-16.
The extension force against resistance was recorded in 23 postures for 12 subjects to find explanations for the decrease in back strength in asymmetric postures. A reduction in muscle force in asymmetric postures was found up to 40%, but was strongly dependent on the plane in which asymmetry occurred, and on the posture to which it referred. A quantitative relationship between the forces exerted in different asymmetric postures is discussed, as a basis for formulating universal ergonomic guidelines for optimal working postures. The reduction in force in different asymmetric postures can be explained by length of the muscle, the activation of the muscle, and the moment angle of the muscle.
- Westgaard, R.; Bjorklund, R. Generation of muscle tension additional to postural muscle load. *Ergonomics*. 1987; 30(6): 911- 23.
This paper presents methods and the first results of experiments designed to test the hypothesis that individuals in many situations generate muscle loads in excess of those necessary to maintain postural stability. Excess muscle loads of this kind are demonstrated in experiments where specific movements are performed with a high level of arousal. Most recordings from the psychophysical tests showed a near identical tension pattern for all muscles tested, with very low variability apart from sudden or slow changes in mean load. There were considerable inter- individual differences in tension patterns, and some implications of these findings in terms of health effects in real-life work situations are discussed.
- Wos, H.; Svensson, L.; Norlander, S. Implementation of double- pulsed holography in evaluation of whole-body vibration. *Ergonomics*. 1991; 34(11): 1357-64.
This study used a unique holographic technique to evaluate the effects of vibration on soft tissues and bones. It was possible to record forced whole-body vibration in humans by holograph interferometry using a double-pulsed ruby laser. The study investigated the manner in which the muscles of the back and vertebral column are affected by vibrations applied to the human buttocks in the sitting position. The subject was exposed to vibration at two frequencies: 40 and 60 Hz (vertical Z axis). Transmission of the vibrations along the subject's back was recorded by means of double-pulsed holography and electromyography.

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Evaluation of the vibration pattern showed that the vibrations are transmitted along the back all the way up to the neck and head. The pattern of vibration in the muscles of the back and vertebral column showed that the greatest effect was exerted on the lumbar region of the back and the area of transition between the thoracic and cervical regions.

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Herrin, G.; Jaraiedi, M.; Anderson, C. Prediction of overexertion injuries using biomechanical and psychophysical models. *American Industrial Hygiene Association Journal*. 1986; 47(6): 322-30.

This paper summarizes a three year epidemiological study conducted in five large industrial plants in order to evaluate the validity of two alternative modeling approaches to overexertion injury prediction. Detailed biomechanical and psychophysical job evaluations were performed for 55 industrial jobs comprised of 2934 potentially stressful manual materials handling tasks. The medical experiences of 6912 incumbent workers were monitored retrospectively for two years and prospectively for one year to establish a data base for comparison of the different models. The results show that each of the models can be used to predict both the incidence and severity of certain overexertion types of injuries such as contact, musculoskeletal and back injuries. The application of these models to identify or design administrative and engineering controls, however, may be limited as a result of the inherent correlation between the available indices and multifaceted jobs.

Jager, M.; Luttmann, A. Biomechanical analysis and assessment of lumbar stress during load lifting using a dynamic 19-segment human model. *Ergonomics*. 1989; 32(1): 93-112.

A dynamic biomechanical human model is presented which allows the quantification of mechanical parameters such as torque, compressive and shear forces, and pressure at the lumbar intervertebral discs. The human model comprises a total of 19 body segments. Various trunk flexions can be analysed due to the provision of 5 joints at the level of the 5 lumbar intervertebral discs. The influence of intraabdominal pressure on spinal load is considered. The inclusion of the influences of gravity and inertia permits the analysis of both static body postures and dynamic body movements. Since the model is 3-dimensional, the lumbar stress can be calculated during both symmetrical tasks in the median sagittal plane as well as during non-symmetrical ones. The influences on spinal stress of trunk inclination and the position of an external load relative to the body are quantified for various load weights up to 50 kg. The torque at the lumbosacral joint L5-S1 lies, dependent on posture and load lever-arm, within the range between 0 and 500 Nm; the compressive force on L5-S1 lies within the range between 0.4 and 10 kN, and the shear force at L5-S1 between 0.2 and 0.9 kN. The influences of lift velocity and jerky movement on lumbar stress are quantified. Simulated humpback and hollow-back postures are studied. The compressive forces at the 5 lumbar intervertebral discs are compared. The validity of the model is examined by comparing the model calculations with the intradiscal pressure measurements taken from the literature. Strength tests on lumbar intervertebral discs and vertebrae are collated from the literature in order to assess the lumbar stress during load lifting. The lumbar ultimate compression strength varies within a wide range. The mean value for a total of 307 lumbar segments amounts to 4.4 kN, the standard deviation to 1.9 kN. In conclusion,

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lumbar compressive force values during lifting fall within the same range as the strength values for the human lumbar spine.

- Jager, M.; Luttmann, A. The load on the lumbar spine during asymmetrical bi-manual materials handling. *Ergonomics*. 1992; 35(7-8): 783-805.
- Previous biomechanical analyses of typical load manipulation tasks were mainly limited to sagittal-plane activities or to static cases. This paper includes the biomechanical determination and assessment of lumbar load during asymmetrical bi-manual materials handling tasks which involve lateral turning of the body, trunk inclination, and sagittal flexion and lateral bending of the spine. Diagonal lifting tasks were analysed for different values for load weight (0-40 kg) and task duration (0.75-1.5 s). Whereas a constant grasp height of 15 cm was assumed, the height for releasing the load differed (50, 100, 150 cm). A dynamic spatial human model ('The Dortmunder') was used for calculating the torque in the sagittal, frontal, and transversal planes through the lumbosacral joint and for determining the compressive and the sagittal and lateral shear force at the L5-S1 disc. The trajectories of body segments and load are computer-simulated on the basis of postures adopted during the movement. During diagonal lifting of loads, lumbosacral torque in the sagittal plane is considerably larger than the lateral bending and torsional torque components. Dynamic analyses result in higher maximum values in the lumbar-load time curves than static analyses. The shorter the time for task execution, the higher the resultant dynamic effects and, in consequence, the higher the lumbar load. Lumbosacral compression and shear increase with increasing load-release heights due to higher acceleration and retardation of body and load when the same grasp position and task duration are assumed. The maximum load-bearing capacity of the lumbar spine was determined on the basis of strength data for isolated lumbar segments provided in the literature. The compressive strength falls within the same range as the compressive forces calculated for asymmetrical lifting of loads up to 40 kg. On account of the wide scattering of the compressive strength values, the main influences were determined (age and gender). At an age of 40 years, strength is approx. 6.7 kN for males and 4.7 kN for females (decrease with age per decade: 1.0 kN males, 0.6 kN females). In order to avoid overestimating an individual's lumbar compressive strength, predicted values should be reduced, e.g., by the standard deviation in the male or female samples (2.6 kN or 1.5 kN). Although only a few maximum shear force values are available in the literature, comparison with the calculated values for diagonal lifting leads to the conclusion that sagittal and lateral shear should not be ignored in the assessment of lumbar load during asymmetrical handling tasks.

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- Han, J.; Goel, V.; Kumar, S. A nonlinear optimization force model of the human lumbar spine. *International Journal of Industrial Ergonomics*. 1991; 8(3): 289-301.

Note: NIOSH Abstract.

The use of optimization techniques for the prediction of forces in structures across a human joint was reviewed, and a new cost function based on the least square concept was proposed. An effort was made to improve the low back biomechanical model by improving the accuracy of the assumptions and selection of an appropriate cost function by comparing them among themselves and with the results reported in the literature. The use of a nonlinear optimization approach with an appropriate cost function has enabled researchers to predict

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forces in various structures, including the disc compression force, using a model that incorporates anatomically correct muscle orientations in the formulation. The present model has also provided an understanding of the relationship between low back pain, the muscle forces, and the repetitive activities involving complex loads. Using this information, the relative risks of various tasks performed in the construction industry can be evaluated. With this new method the predicted muscular forces satisfy the physiological requirement that the forces in the left side of the muscles be smaller in magnitude than the corresponding right side muscles for the complex loading case considered. The development of reliable and realistic biomechanical models, in addition to helping to understand spinal biomechanics and the possible causation of low-back pain, provides a mechanism for industrial task design and scheduling. Appropriate implementation of such a strategy could play a significant role in controlling low-back pain problems in the construction industry.

Karhu, O.; Harkonen, R.; Sorvali, P.; Vepsalainen, P. Observing work postures in industry: examples of OWAS application. *Applied Ergonomics*. 1981; 12(1): 13-17.

A practical method for identifying and evaluating poor working postures, i.e., the Ovako Working Posture Analysing System (OWAS), was presented in an earlier paper. The application of the method is here described by means of two examples. One is a case study of bricklaying undertaken by members of an ergonomics training course, in which a marked improvement in working posture was achieved by OWAS analysis of critical activities. The second illustrates the effect of setting up a multidisciplinary group in order to develop an alternative method for the installation and maintenance of steel mill equipment. In both examples, application of the OWAS method led to improved posture in the situations studied, and to the likelihood of its wider industrial use.

Kivi, P.; Mattila, M. Analysis and improvement of work postures in the building industry: application of the computerized OWAS method. *Applied Ergonomics*. 1991; 22(1): 43-48.

A study was conducted to analyze work postures in building construction by using the Ovako Working Posture Analysing System (OWAS) method, to develop a portable computer system of the OWAS method and to test it during the experiment, to improve the work postures identified as poor, and to apply the results as part of an ergonomics training program of the company. The jobs evaluated included cleaner, bricklayer, construction worker, timberman, concrete layer, concrete reinforcement worker, cement worker, repair worker, electrician, plumber, isolation worker, and painter, and were selected through the results of Systematic Workplace Investigations made by occupational health personnel at various construction sites. The computer system developed consisted of posture coding in the field, data transfer to the personal computer, and data analysis and presentation through the personal computer. The OWAS analysis gave the opportunity to compare the jobs evaluated according to the number of postures which need to be corrected soon or immediately. The computer program gave also a detailed presentation about the distribution of posture observations into the categories in need of corrective measures. For every job analyzed, the proportion of poor postures among all the tasks involved in the job in question was also presented. The program pinpointed the most critical postures for every task, and the activity observations also revealed what the worker was doing while these critical postures occurred. Out of over 6000 postures observed, there were 101 postures falling into OWAS category 4, corrective measures needed immediately. The most common category 4 work postures observed included

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bent back, both arms above shoulders, body moved by the lower limbs, and the force required to handle a mass from 10 to 20 kilograms.

Wangenheim, M.; Samuelson, B.; Wos, H. ARBAN -- A force ergonomic analysis method. N. Corlett, J. Wilson, & I. Manenica (Eds). *The Ergonomics of Working Postures. Models, Methods and Cases*. London: Taylor & Francis; 1986: 243-55. Note: NIOSH Abstract.

A description is provided of the updated ARBAN method, a force ergonomic analysis method used to identify, define and document problems occurring at the workplace, design and develop machines and products, and plan and improve workplaces and production lines. The data generated by the application of the ARBAN method can be evaluated by engineers, designers and health care workers as well as other individuals with limited knowledge of ergonomics. The structure of the method involves a comprehensive time study, documentation at the workplace without disturbing the workers (using a video camera system), assessment of postural loads by means of a guide, and assessment of force load in terms of numerical values relating to predetermined stress categories. In this method, vibration is assessed in a manner similar to that used to assess force load, while static load and the recovery phase are assessed using modified models developed earlier by others. The overall analysis is presented in the form of 15 curves and one table. The method is applicable primarily to heavy mobile work situations and it is not yet well set for precision work. The method has been used to compare alternative scaffolding methods. The results obtained have detailed the combined work sequences for each part of the body, for different types of scaffolds. Another study has been performed to determine the optimal man/machine combination in laying concrete slabs, by comparing various concrete laying methods.

Wangenheim, M.; Samuelson, B. Automatic ergonomic work analysis. *Applied Ergonomics*. 1987; 18: 9-15.

To reduce occupation-related diseases, injuries and impairments to the musculoskeletal system, and ergonomics analysis of the work process is necessary. The authors describe a project to develop an automatic ergonomic work analysis method using existing and developed models of work stress factors. It was designed to record the work accurately without disrupting activities, and describe the situation so that production engineers and designers can be supplied with basic information for ameliorative measures. The system determines such parameters as the position and movement of 14 parts of the body and such measurements as force exerted, range of movement and static stress. A pilot study with a prototype of the system has been completed and tested with simple word sequences.

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Burdorf, A. Sources of variance in exposure to postural load on the back in occupational groups. *Scandinavian Journal of Work, Environment & Health*. 1992; 18(6): 361-67.

The variability of exposure to postural load on the back was studied in five occupational groups. A random sample of workers in each group was observed for two periods of 30 min during a shift, their posture being classified every 20 s. The estimated percentage of time spent in trunk flexion and rotation formed the principal measures of exposure. The partitioning of the total variability of

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exposure showed that occupational group status was the principal source of variance. The between-group variance accounted for 47 and 72% of the total variability of exposure to trunk flexion and rotation, respectively. The corresponding percentages were 29 and 16% for the within-worker variance of trunk flexion and rotation and 24 and 12% for the between-worker variance. This type of analysis of the sources of exposure variability may help to establish appropriate measurement strategies for exposure to postural load on the back in epidemiologic studies on low-back pain.

Burdorf, A.; Laan, J. Comparison of methods for the assessment of postural load on the back. *Scandinavian Journal of Work, Environment & Health*. 1991; 17(6): 425-29.

A questionnaire, a self-administered log, and an observational method were simultaneously applied in the workplace of 35 mechanical repair men to assess exposure to strenuous postures and movements of the back. The average duration of time spent in a standing position was considerably underrated by the workers, while the duration of sitting was strongly overrated when compared with the ratings obtained with the observational method. The workers' ratings of duration with a bent or rotated trunk was two to four times lower than the observed duration. The estimate of the average number of lifts performed per hour was more than four times higher in the questionnaire than in the log. The same striking difference was found for the frequency of bending or rotating of the trunk. These results suggest that the reliability of questionnaire methods for the assessment of postural load in epidemiologic studies is probably not very high.

Burdorf, A. Exposure assessment of risk factors for disorders of the back in occupational epidemiology. *Scandinavian Journal of Work, Environment & Health*. 1992; 18(1): 1-9.

This review describes methods for assessing exposure to postural load of the back in occupational epidemiologic studies. Eighty-one original articles were selected that presented information on the prevalence of back disorders in occupational groups. In 47 (58%) of these studies no data on exposure to risk factors were given. In the remaining 34 studies (42%) exposure assessment was performed by questionnaire (33%), observation (9%), and direct measurement (5%). Measures of exposure were predominantly presented at the nominal and ordinal levels. It is argued that in most epidemiologic studies on disorders of the back in occupational groups the quality of exposure data is poor. Quantitative measurement methods need to be developed for application in occupational epidemiology.

Hagberg, M. Exposure variables in ergonomic epidemiology. *American Journal of Industrial Medicine*. 1992; 21(1): 91-100.

The ergonomic field is rather new to epidemiology and ergonomists are usually without knowledge in epidemiology. This review presents exposure variables used in ergonomic epidemiology, especially those that concern mechanical trauma to the musculoskeletal system at the workplace and suggests how to approach exposure definition, exposure assessment, and exposure evaluation. The exposure variables that define the exposure can be divided into five main categories: posture, motion/repetition, material handling, work organization, and external factors. There is no consensus on how different exposure variables should be pooled and interpreted as single estimates of cumulative exposure. For future ergonomic epidemiology, it is suggested that exposure be described by different exposure variables giving an exposure profile and not by a single estimate of the exposure. The possibly short time-response relationship for many

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work-related musculoskeletal disorders provides a challenge in evaluating different cumulative exposure measures. These measures could easily turn into effective hazard surveillance tools. Large etiological fractions found for some musculoskeletal diseases indicate a great potential for ergonomic interventions.

Wickstrom, G. Drawbacks of clinical diagnoses in epidemiologic research on work-related musculoskeletal morbidity. *Scandinavian Journal of Work, Environment & Health*. 1982; 8(Suppl 1): 97-99.

Register data on musculoskeletal morbidity in various occupational groups are difficult to use in evaluating possible effects of work because of the inexactness of the definition of the clinical diagnoses and their use in ordinary medical practice. A more precise classification of disorders and ailments would provide a better possibility to establish those relations between work and disease which do exist. Internationally recommended methods for epidemiologic research on occupational musculoskeletal disorders are needed.

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Anderson, J. Shoulder pain and tension neck and their relation to work. *Scandinavian Journal of Work, Environment & Health*. 1984; 10(6): 435-42.

Reliable information about shoulder girdle pain in relation to work practices is difficult to obtain from routinely acquired statistics. On the basis of data obtained from a special study of 2,648 manual workers from jobs without special demands for neck or shoulder activity, an estimate has been made of the size of the problem. The results indicate that 23% of a manual workforce reported having suffered from pain in the neck, shoulder, or upper arm on at least one occasion during their worklife and that 15% had had such pain during the year prior to the study. These pains arose through a number of causes collectively grouped as shoulder girdle pain. The relative importance of trivial injuries, degenerative changes, and structural abnormalities is considered along with the possible work-related role in contributing to the onset of such painful syndromes. In light of these possibilities the contribution which primary preventive measures could make to reducing the problem by altering the posture at work is discussed, and an indication is given of the likely limitation of secondary preventive measures (screening) in this field. On the other hand there is room for increased diagnostic accuracy to ensure better management and rehabilitation for those with prolonged or recurrent painful symptoms.

Bergenudd, H.; Lindgarde, F.; Nilsson, B.; Petersson, C. Shoulder pain in middle age. A study of prevalence and relation to occupational work load and psychosocial factors. *Clinical Orthopaedics & Related Research*. 1988; 231: 234-38.

Studies on 574 subjects demonstrated the prevalence of shoulder pain and its relationship to occupational work load and psychosocial factors. The prevalence of shoulder pain was 14% (13% men, 15% women). Women had more often myalgias with a tenderness on palpation of the shoulder muscles and rhizopathia-brachialgia type of pain, whereas men had mainly intraarticular pain. Three percent had been on sick leave because of shoulder pain in the year preceding the examination and 5% had a reduced range of shoulder joint motion. The subjects with shoulder pain were less satisfied with their jobs and had been less successful in a childhood intelligence test. No difference could be demonstrated between subjects with or without shoulder pain in estimated overall work load, but women with signs of supraspinatus tendinitis more often had jobs with physical demands. [The population studied was divided into three groups,

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light physical work, moderate physical work, and heavy physical work. The latter group included carpenters, bricklayers, and other heavy industry workers.]

Hagberg, M. Occupational musculoskeletal stress and disorders of the neck and shoulder: a review of possible pathophysiology. *International Archives of Occupational & Environmental Health*. 1984; 53(3): 269-78.
Disorders and complaints in the neck and shoulder regions are common among industrial workers and are often attributed to occupational musculoskeletal stress. The possible pathophysiological mechanism of occupational stress on the neck and shoulders is reviewed. A mechanical origin for cervical disc degeneration and osteoarthritis is reported for a few occupational groups. However, a mechanical origin for osteoarthritis is debatable. A work posture involving elevated arms may accelerate degeneration of shoulder tendons through impairment of circulation due to static tension and humeral compression against the coracoacromial arch. Furthermore, work tasks with repetitive arm movements may evoke shoulder tendinitis or tendo-vaginitis, probably due to friction. Three possible routes to neck-shoulder muscular pain are discussed; mechanical failure, local ischemia and energy metabolism disturbance.

Hagberg, M. Shoulder pain-pathogenesis. N. Hadler (Ed.). *Clinical Concepts in Regional Musculoskeletal Illness*. Orlando, Florida: Grune & Stratton; 1987: 191-200.
An examination of the pathogenesis of shoulder pain that focuses on degenerative joint disorder, tendinitis, myofascial disorder, and neurovascular disorder in the shoulder.

Hagberg, M.; Wegman, D. Prevalence rates and odds ratios of shoulder-neck diseases in different occupational groups. *British Journal of Industrial Medicine*. 1987; 44(9): 602-10.
The aim of the present study was to evaluate the association and impact of occupational exposure and diseases of the shoulder and neck. Prevalence rates, odds ratios, aetiological fractions, and their confidence intervals were computed for pooled and non-pooled data of previous published reports. By comparison with office workers and farmers, dentists had an increased odds ratio for cervical spondylosis (two studies) and for shoulder joint osteoarthritis. Meat carriers, miners, and "heavy workers" also had significantly higher rates of cervical spondylosis compared with referents. Compared with iron foundry workers, civil servants had a significant odds ratio (4.8) of cervical disc disease and a 0.79 aetiological fraction. Whether this was due to exposure or healthy worker effect was not clear. In four occupational groups with high shoulder-neck load an odds ratio of 4.0 was found for thoracic outlet syndrome with an aetiological fraction of 0.75. Rotator cuff tendinitis in occupational groups with work at shoulder level (two studies) showed an odds ratio of 11 and an aetiological fraction of 0.91. Keyboard operators had an odds ratio of 3.0 for tension neck syndrome (five studies). Unfortunately, owing to the scanty description of the work task, the exposure could be analysed only by job title. Examination of published reports shows clearly that certain job titles are associated with shoulder-neck disorders. High rates and aetiological fractions for rotator cuff tendinitis and tension neck syndrome suggest that preventive measures could be effective. Although job descriptions are brief, the associations noted suggest that highly repetitive shoulder muscle contractions, static contractions, and work at shoulder level are hazardous exposure factors. In reports of cross sectional studies of occupational shoulder-neck disorders, presentation of age, exposure, and effect distribution may help for future meta-analysis.

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Herberts, P.; Kadefors, R.; Hogfors, C.; Sigholm, G. Shoulder pain and heavy manual labor. *Clinical Orthopaedics & Related Research*. 1984; 191: 166-78.

The problem of the increasingly common shoulder pain syndromes in industry was investigated by biomechanic and epidemiologic methods. Rotator cuff tendinitis constitutes a major problem in people with arduous occupations, i.e., shipyard welders (prevalence ratio, 18.3%), and steel plateworkers (16.2%). Static work seems to induce symptoms at an earlier age. The clinical diagnosis was supraspinatus tendinitis. The biomechanic studies confirmed the view that the shoulder muscles are heavily loaded when the arm is elevated. Excessive hand tool mass increases the strain markedly in some muscles, particularly the supraspinatus and the infraspinatus. The hypovascularity of the supraspinatus tendon is then likely to be accentuated by high intramuscular pressure that reduces the blood flow through the muscle. The strain on the supraspinatus muscle in overhead work is an important factor contributing to prolonged shoulder disability. An analysis of the distribution of loads imposed on the shoulder in practical working situations can be based on observations of working postures and external forces.

Kilbom, A. Intervention programmes for work-related neck and upper limb disorders: strategies and evaluation. *Ergonomics*. 1988 May; 31(5): 735-47.

In this review the design and results of controlled interventions against work-related neck and upper limb disorders are discussed. The method of intervention -- workstation redesign, work reorganization, worker training and education -- is related to the outcome. The results should be evaluated using a range of intermediate and end-point variables. Very little attention has yet been paid to the cost effectiveness of interventions and unsuccessful interventions are seldom reported, which makes an evaluation of the 'most successful design' incomplete. The use of reference groups for control of background variables, like fluctuations in work output and staff turnover is emphasized. The role of researchers, as active interveners or as passive recorders of effects is discussed, and the importance of an active contribution from management and employers is stressed.

Olson, P. Musculoskeletal disorders of the neck-shoulder region related to working positions in the construction industry. *Bygghalsan Bulletin*. : 1987-05-01.
Note: English Abstract.

An abstract of a study of 2,448 male workers in the Swedish Construction Industry that answered a self administered questionnaire about how many hours/week they work with their arms above shoulder level, and if they suffer from musculoskeletal disorders in the neck-shoulder region. Working more than 10 hours/week with the arms above shoulder level significantly increased musculoskeletal neck and/or shoulder disorders in all age categories above 30 years of age. Almost 50% of the construction workers work more than 10 hours/week with arms above shoulder level, and in certain subgroups such as house-painters, insulation workers, electricians, plumbers and platers, more than 2/3s work more than 10 hours/week in such positions. These facts call for a change in working methods and organization in order to prevent further work-related disorders.

Sommerich, C.; McGlothlin, J.; Marras, W. Occupational risk factors associated with soft tissue disorders of the shoulder: a review of recent investigations in the literature. *Ergonomics*. 1993; 36(6): 697-717.

Cumulative trauma illness currently accounts for over half of all occupational

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illness in the United States. From 1987 to 1989 there was a 100% increase in the reported number of cases of cumulative trauma illness (Bureau of Labor Statistics 1990). Shoulder region pain ranks second only to low back and neck pain in clinical frequency, and the occurrence of occupational shoulder illness is on the rise. This paper summarizes findings of a subset of recent epidemiologic, laboratory, and field studies conducted in order to identify occupational risk factors for cumulative trauma disorders (CTDs) of the shoulder region. These studies have identified the following risk factors as being associated with particular shoulder pain syndromes: awkward or static postures, heavy work, direct load bearing, repetitive arm movements, working with hands above shoulder height, and lack of rest. The paper begins with a discussion of several shoulder disorders, includes problems in studying cumulative trauma, presents results of recent studies, and concludes with suggested ergonomic controls that could help to reduce the incidence of shoulder disorders, by eliminating or reducing exposure to the associated risk factors.

Stock, S. Workplace ergonomic factors and the development of musculoskeletal disorders of the neck and upper limbs: a meta-analysis. *American Journal of Industrial Medicine*. 1991; 19(1): 87-107.

In the past 10 years there has been growing awareness among occupational health professionals worldwide of the large burden of illness associated with musculoskeletal disorders of the neck and upper limbs. It has been suggested that these disorders are associated with highly repetitive work and are due, at least in part, to ergonomic factors. This review examines the epidemiologic evidence of the relationship between workplace ergonomic factors such as repetition, force, static muscle loading, and extreme joint position and the development of muscle, tendon, and nerve entrapment disorders of the neck and upper limbs of exposed workers. An extensive search for relevant studies was undertaken. Of 54 potentially relevant studies identified, three met the a priori inclusion criteria. The validity of these studies was assessed, and one study was found to have major flaws. Criteria to demonstrate causality were also applied and were met in the most rigorously conducted study. When the results of these studies are compared and aggregated where appropriate, they provide strong evidence of a causal relationship between repetitive, forceful work and the development of musculoskeletal disorders of the tendons and tendon sheaths in the hands and wrists and nerve entrapment of the median nerve at the carpal tunnel. The comparison of exposed to controls for hand/wrist tendinitis gives an unadjusted common odds ratio of 9.1 (95% CI 4.9-16.2). The adjusted odds ratio for carpal tunnel syndrome is 15.5 (95% CI 1.7-141.5) based on the most rigorous study.

Wallace, M.; Buckle, P. Ergonomic aspects of neck and upper limb disorders. *International Reviews of Ergonomics*. 1987; 1: 173-200.

This review paper considers the nature of the problem of neck and upper limb disorders with respect to the diagnoses and classification of classic musculoskeletal disorders and those which are less well defined. In particular it examines the collective terms which have arisen in recent years. Methodological difficulties in undertaking epidemiological studies of these disorders are described with reference to a number of investigations. The paper argues that at present there is a lack of theory linking specific health effects to specific causal factors, and considers the evidence for associated risk factors. Links with occupation, posture, movement and force, task dimensions, work content and psychological factors are discussed with reference to the current literature. The role of individual characteristics and the use of screening tests is similarly

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reviewed. The paper continues by examining the results of a number of intervention studies and examines their effectiveness. The conclusions emphasize the importance of static load and constrained postures as associated risk factors and, in addition, identify a number of areas for future research.

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Johansson, H.; Sojka, P. Pathophysiological mechanisms involved in genesis and spread of muscular tension in occupational muscle pain and in chronic musculoskeletal pain syndromes: a hypothesis. *Medical Hypotheses*. 1991; 35: 196-203.

This paper introduces a pathophysiological model for the cause of muscular tension and pain in occupational pain syndromes and chronic musculoskeletal pain syndromes, which also might clarify why these conditions have a tendency to perpetuate themselves and spread from one muscle to another. The model can briefly be described as follows. Metabolites produced by (static) muscle contractions stimulate group III and IV muscle afferents, which activate gamma-motoneurons projecting to both homonymous and heteronymous muscles. The gamma-motoneurons influence the stretch sensitivity and discharges of secondary and primary spindle afferents. Increased activity in the primary muscle spindle afferents enhances the muscle stiffness, which leads to further production of metabolites in both homo- and heteronymous muscles. Increased activity in secondary spindle afferents, which project back to the gamma-system, constitutes a 'built in' second positive feedback loop which may perpetuate the condition with less 'support' from activity in group III and IV muscle afferents.

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Anderson, J. Arthrosis and its relation to work. *Scandinavian Journal of Work, Environment & Health*. 1984; 10(6): 429-33.

Data are presented to illustrate the inadequacy of routinely collected data on osteoarthritis when disability and handicap are considered as distinct from impairment. In a series of prevalence studies of mixed manual workers aged 15 to 65 years in the United Kingdom 11% had diagnosable osteoarthritis of the limbs, 2% had generalized osteoarthritis, and 11% had vague pains of undetermined diagnosis in the limb joints. Annual sickness absence was 580 d/100 affected men for those with local osteoarthritis and 539 d/100 and 80 d/100, respectively, for those with generalized osteoarthritis and vague limb pain. These and other indicators of disablement (hospital attendance and admission, self therapy, and consultation with general practitioners) suggest that osteoarthritis makes a significant contribution to the handicap of manual workers. There was no significant difference in the prevalence rates between skilled and unskilled dockyard workers; this finding contrasts with the significantly higher rates for osteoarthritis at all ages among coal miners working in awkward postures in confined spaces than among weight-lifting manual workers in other occupations. Direct observation and assessment of specific tasks support the hypothesis that posture may be more important than weight lifting as a risk factor in the onset of osteoarthritis.

Croft, P.; Cooper, C.; Wickham, C.; Coggon, D. Defining osteoarthritis of the hip for

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epidemiologic studies. *American Journal of Epidemiology*. 1990; 132(3): 514-22. The authors compared seven radiologic indices of hip osteoarthritis to establish which provided the best definition of the disease for epidemiologic purposes. Hip joints were assessed from intravenous urograms taken in a British hospital between 1982 and 1987 in 1,315 men aged 60-75 years. The indices examined were an overall qualitative grading of osteoarthritis, four measures of joint space, the maximum thickness of subchondral sclerosis, and the size of the largest osteophyte. Minimal joint space (i.e., the shortest distance between the femoral head margin and the acetabulum) was the index most strongly associated with other radiologic features of osteoarthritis. Among a subset of 759 men who answered a questionnaire about symptoms, the overall qualitative grading, minimal joint space, and thickness of subchondral sclerosis were the radiologic indices most predictive of hip pain. Within- and between-observer repeatability were tested in a subset of 50 subjects. Measures of joint space were more reproducible than other indices. These data suggest that, at least in men, minimal joint space is the best radiologic criterion of hip osteoarthritis for use in epidemiologic studies.

Croft, P.; Cooper, C.; Wickham, C.; Coggon, D. Osteoarthritis of the hip and occupational activity. *Scandinavian Journal of Work, Environment & Health*. 1992; 18(1): 59-63.

This case-referent study investigated the relation between hip osteoarthritis and occupational activity. The subjects were 60- to 75-year-old men who had undergone intravenous urography. Interviews were obtained for 245 cases who had a hip replacement for osteoarthritis or a joint space of less than or equal to 2.5 mm and 294 referents whose joint space was greater than or equal to 3.5 mm in both hips. No clear associations were found in an analysis of all the cases, but severe disease (hip replacement for osteoarthritis or a joint space of less than or equal to 1.5 mm) was more common in the farmers, especially in those with greater than or equal to 10 years in agricultural work (odds ratio (OR) 2.0, 95% confidence interval (95% CI) 0.9-4.4). Severe disease was also associated with prolonged standing at work (OR 2.7, 95% CI 1.0-7.3) and heavy lifting (OR 2.5, 95% CI 1.1-5.7). These associations could not be explained by obesity or sporting activity. The findings suggest an increased risk of degenerative hip disease for farmers and indicate that mechanical overloading may contribute to its pathogenesis. [The association between severe osteoarthritis of the hip and construction workers and laborers (093--098, 113; N = 9) was 1.5 OR, 95% CI 0.7-3.4. For construction workers and laborers (N = 7) with 1-9 years of employment, the OR was 3.3, CI 1.2-9.2.].

Felson, D. Epidemiology of hip and knee osteoarthritis. *Epidemiologic Reviews*. 1988; 10: 1-28.

This review has focused on the prevalence and risk factors associated with knee and hip osteoarthritis. Risk factors for knee osteoarthritis are obesity and major injury, and knee osteoarthritis probably fits into the generalized osteoarthritis diathesis. Repetitive use, such as in jobs requiring heavy labor and knee bending, probably increases the risk of knee osteoarthritis. Hip osteoarthritis is probably frequently secondary to developmental defects. As Rothman has pointed out in discussing causation, this does not necessarily mean that the same factors do not also contribute to causing hip osteoarthritis. Yet, it appears that, in many cases, developmental defects are severe enough to be sufficient causes of hip osteoarthritis. To delineate other causes, it may be necessary to examine risk factors separately in those with and in those without developmental disease. Although large epidemiologic studies are best able to identify the

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relative contributions of specific risk factors while controlling for other risk factors, new studies need to focus on important unresolved questions. First, longitudinal studies with comprehensive follow-up using repeated radiographic assessments are needed to identify factors that cause development of disease or the onset of symptoms. Second, cohorts with early and possibly asymptomatic disease need to be followed to determine the causes of progression or regression of disease and the natural history of disease. Such cohorts may include those at high risk of injury such as sports enthusiasts or manual laborers.

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Hagberg, M. Electromyographic signs of shoulder muscular fatigue in two elevated arm positions. *American Journal of Physical Medicine*. 1981; 60(3): 111-21.

Electromyographic signs of shoulder muscular fatigue were studied in abduction and forward flexion at right angle in the shoulder joint for seven subjects. The myoelectric signal was recorded by surface electrodes for the upper part of the trapezius muscle, the infraspinatus muscle, the middle and anterior part of the deltoid muscle and the biceps brachialis muscle. Bipolar wire electrodes were used for the supraspinatus muscle. By a moving window t-test the duration to the first significant increase of amplitude (RMS) or decrease of mean power frequency (MPF) were determined. The torque produced by the mass of the arm in the two studied elevated arm positions was found to exceed 10 per cent of the maximal voluntary contraction (MVC) for all subjects. For most subjects the supraspinatus and the upper part of the trapezius muscle, revealed significant signs of fatigue after five minutes in the two positions and short time constants of myoelectric amplitude changes. Furthermore electromyographic signs of fatigue developed within a minute for all subjects in the forward flexion (supraspinatus muscle) and in the abduction position (upper part of the trapezius muscle).

Herberts, P.; Kadefors, R.; Broman, H. Arm positioning in manual tasks. An electromyographic study of localized muscle fatigue. *Ergonomics*. 1980; 23(7): 655-65.

Myoelectric activity in four different shoulder muscles was collected and interpreted as indirect indicators of the load in eight different arm positions. The power spectrum changes associated with localized muscle fatigue were measured using a new dedicated instrument. Localized muscle fatigue was present in all muscles, in overhead and shoulder level work, and in some cases in waist level work as well. For instance, in overhead work, the supraspinatus load was significantly affected by elbow positioning. The infraspinatus muscle held the highest fatigue effects of all muscles investigated. The results indicate the possibility of finding positions entailing reduction of the total muscular load in different working situations.

Herberts, P.; Kadefors, R.; Hogfors, C.; Sigholm, G. Shoulder pain and heavy manual labor. *Clinical Orthopaedics & Related Research*. 1984; 191: 166-78.

The problem of the increasingly common shoulder pain syndromes in industry was investigated by biomechanic and epidemiologic methods. Rotator cuff tendinitis constitutes a major problem in people with arduous occupations, i.e., shipyard welders (prevalence ratio, 18.3%), and steel plateworkers (16.2%). Static work seems to induce symptoms at an earlier age. The clinical diagnosis was supraspinatus tendinitis. The biomechanic studies confirmed the view that the shoulder muscles are heavily loaded when the arm is elevated. Excessive

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hand tool mass increases the strain markedly in some muscles, particularly the supraspinatus and the infraspinatus. The hypovascularity of the supraspinatus tendon is then likely to be accentuated by high intramuscular pressure that reduces the blood flow through the muscle. The strain on the supraspinatus muscle in overhead work is an important factor contributing to prolonged shoulder disability. An analysis of the distribution of loads imposed on the shoulder in practical working situations can be based on observations of working postures and external forces.

Lindberg, J.; Wos, H.; Norlander, S.; Jakus, R. Support stand for hand-held tools used for overhead work. *Bygghalsan Bulletin*. : 91-09-16.

Note: English Abstract.

An abstract of a study demonstrating the advantages of a support stand/belt for hand-held tools for overhead work. Long term work involving continuous lifting of the arms subjects certain shoulder muscles to high loads, and muscular fatigue results quickly. Since many construction workers suffer with load injuries in the neck and shoulder region, Bygghalsans Forskningsstiftelse designed a support stand with a waist belt for hand-held tools in order to facilitate work above shoulder height and prevent the development of load and vibration injuries.

Olson, P. Musculoskeletal disorders of the neck-shoulder region related to working positions in the construction industry. *Bygghalsan Bulletin*. : 1987-05-01.

Note: English Abstract.

An abstract of a study of 2,448 male workers in the Swedish Construction Industry that answered a self administered questionnaire about how many hours/week they work with their arms above shoulder level, and if they suffer from musculoskeletal disorders in the neck-shoulder region. Working more than 10 hours/week with the arms above shoulder level significantly increased musculoskeletal neck and/or shoulder disorders in all age categories above 30 years of age. Almost 50% of the construction workers work more than 10 hours/week with arms above shoulder level, and in certain subgroups such as house-painters, insulation workers, electricians, plumbers and platers, more than 2/3s work more than 10 hours/week in such positions. These facts call for a change in working methods and organization in order to prevent further work-related disorders.

Sigholm, G.; Herberts, P.; Almstrom, C.; Kadefors, R. Electromyographic analysis of shoulder muscle load. *Journal of Orthopaedic Research*. 1984; 1(4): 379-86.

The influence of hand tool weight and arm position on shoulder muscle load was studied by electromyography. The investigation was made to facilitate recommendations on work place design. The aim is to reduce the occurrence of occupational shoulder disorders in industry. Nine volunteers held 21 different arm positions with the hand over waist level. In each position, the hand was loaded with 0, 1, and 2 kg. Each load was maintained for 15 s. The myoelectric activity in six shoulder muscles was recorded and analyzed automatically with respect to the amplitude. The results indicate that the degree of upper arm elevation is the most important parameter influencing shoulder muscle load. Short rotator muscles stabilizing the shoulder joint were found to be more hand-load dependent than the deltoid muscle. The ergonomic implications of this study are that work situations should be designed so that the arm can be kept close to the body and the hand load minimized.

PAINTING

PAINTING

Cederqvist, T.; Ortengren, R. An electromyographic study of the effect of a new tool for ceiling painting on hand grip force. 1985 Linköping Applications of Biomechanics: A Precongress Meeting to the X'th International Congress of Biomechanics, June 12-15, 1985 Linköping, Sweden. 3 pages.

A study of the ergonomic benefits of a new handle grip for use in painting overhead. The results of the study show that the load on the FDS muscle is reduced when ceilings are painted by means of a roller on a pole and the pole is supplied with the relief disk. The other muscles show similar amplitude and the perceived exertion in the arm and shoulder is significantly reduced so there is no shift of the load to other muscles.

Kivimäki, J.; Riihimäki, H.; Hanninen, K.; Knee disorders in carpet and floorlayers and painters. *Scandinavian Journal of Work, Environment & Health*. 1992; 18(5): 310-06.

In an evaluation of the effect of kneeling work on the knees, 168 actively working carpet and floor layers and 146 house painters were examined with the aid of a questionnaire, a clinical examination, and radiography. Reported knee pain, knee accidents, and treatment regimens for the knees were more common among the carpet and floor layers than among the painters. Radiographic changes of the tibiofemoral joint were noted equally in the two occupational groups, but osteophytes of the patella were more common among the carpet and floor layers than among the painters. In a multivariate analysis, the determinants of osteophytosis of the knee were age, occupation, knee accidents, and smoking workers. This study indicates that kneeling work increases the risk of knee disorders and such radiographic changes that might be an initial sign of knee degeneration.

Niskanen, T. Accidents and minor accidents of the musculoskeletal system in heavy (concrete reinforcement work) and light (painting) construction work. *Journal of Occupational Accidents*. 1985; 7: 17-32.

The aim of this study was to clarify the differences between concrete reinforcement workers and painters in the frequency, causes, and types of accidents and minor accidents affecting the musculoskeletal system. Accident report forms sent by construction firms to insurance companies were analyzed in detail. Accidents led to at least a 3-day absence from work. The incidence rate (accidents x 1,000/number of workers) of accidents affecting the musculoskeletal system was four times as high among the reinforcement workers (124) than among the painters (30). Minor accidents affecting the musculoskeletal system were reported five times more frequently by the reinforcement workers (1.9 minor accidents/1,000 workhours) than by the painters (0.4 minor accidents/1,000 workhours). Altogether 440 man months of reinforcement workers and 429 man months of painters were covered. The accidents and minor accidents were classified according to the following categories: work phase; work posture/ work movement at moment of occurrence; ultimate event of occurrence; the part of body injured; and the injury.

Nordin, M.; Ortengren, R.; Envall, L.; Andersson, G. The influence of paint characteristics on the workload produced by painting ceilings. *Ergonomics*. 1984; 27(4): 409-23.

Note: NIOSH Abstract.

The influence of traditional paint and lighter paint on the work load of professional painters during ceiling painting was investigated. Eleven

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professional male painters with long work experience participated in the study. The work task during the testing session consisted of painting a ceiling with a roller on a pole for a 30 minute period. The area to be painted was a concrete ceiling with a height of 2.2 meters. Painting of this ceiling represented a common work task. All subjects participated in two measurement sessions held on 2 consecutive days. Five subjects used a traditional heavier paint with a density of 1.52 kilograms per liter (kg/l) during the first test session, and six subjects began with a lighter paint of 0.95 kg/l. Each subject was given a new roller at the beginning of the first test session and used this roller during both sessions. During each test session, oxygen consumption, heart rate, number of times the roller was dipped, and estimates of perceived work load were measured. The rolling motion was performed mainly with the arms and shoulders. The mean areas painted with the heavier and lighter paint were 62.9 and 76.9 square meters, respectively. The mean amount of paint used as determined by weight was 24.1 kg for the heavier paint and 15.5 kg for the lighter paint. The mean number of roller dips was about the same for both paints. The mean heart rate values for the heavier and lighter paints were 142 and 140 beats per minute, respectively. A 20 percent higher energy consumption was found when the heavier paint was used. The authors conclude that painting with a light paint significantly decreases the perceived workload and the specific energy consumption per painted surface area.

Riihimaki, H. Back pain and heavy physical work: a comparative study of concrete reinforcement workers and maintenance house painters. *British Journal of Industrial Medicine*. 1985; 42(4): 226-32.

In an investigation of the effect of heavy physical work on the back 217 concrete reinforcement workers aged 25-54 and a reference group of 202 house painters of similar age were interviewed about their back symptoms. Data on occupational history, accidents, and leisure time activities were collected with a questionnaire. The cumulative incidence rate of sciatic pain was significantly higher among the reinforcement workers than the painters. As regards the occurrence of lumbago and non-specific back pain, however, the groups were alike. In both occupational groups sciatic pain during the previous 12 months was associated with earlier back accidents (odds ratio 2.8, 95% confidence interval 1.8-4.5). The accident rate of the reinforcement workers was higher than that of the painters, and this difference seemed to explain their higher rate of sciatic pain.

Riihimaki, H.; Mattsson, T.; Zitting, A.; Wickstrom, G.; Hanninen, K.; Waris, P.

Radiographically detectable degenerative changes of the lumbar spine among concrete reinforcement workers and house painters. *Spine*. 1990; 15(2): 114-19. In this study of lumbar degeneration and the role of mechanical loading in its development, lateral lumbar radiographs of 216 concrete reinforcement workers and 201 house painters aged 25-54 years were examined. Disc space narrowing occurred at about 10 years and spondylophytes at about 5 years younger age in the former than in the latter group. Risk ratios (RR) were estimated from the regression coefficients of logistic regression models. RR for the univariate effect of occupation on disc space narrowing was 1.8, and adjustment for age, earlier back accidents, height, body mass index and smoking had only a minor effect on this relationship, adjusted RR 1.8. The crude RR for spondylophytes was 1.5, and the adjusted RR 1.6. Earlier back accidents showed a significant univariate relationship with DSN, but in multivariate analysis this variate did not retain its significance. It was concluded that heavy physical work enhances the degenerative process of the lumbar spine. Materials handling and postural loading are proposed to be occupational factors of importance in the

PAINTING

development of both disc space narrowing and spondylophytes.

Riihimaki, H.; Wickstrom, G.; Hanninen, K.; Luopajarvi, T. Predictors of sciatic pain among concrete reinforcement workers and house painters--a five-year follow-up. *Scandinavian Journal of Work, Environment & Health*. 1989; 15(6): 415-23.

In a study of the association of occupation and several other determinants with the occurrence of sciatic pain, 167 concrete reinforcement workers and 161 house painters were followed for five years. Base-line data were obtained with a questionnaire, an interview on back symptoms, a clinical examination, and a radiograph of the lumbar spine. Follow-up data on back symptoms were obtained with a postal questionnaire. Concrete reinforcement work was associated with an increase in the risk of sciatic pain, in both a cross-sectional and a prospective study. Reported back accidents contributed to the risk of sciatic pain. Previous history of back symptoms was the most powerful predictor of sciatic pain prospectively. Degenerative changes were related to sciatic pain in retrospect, but prospectively this relationship was weaker. Body height and history of stress episodes showed some association with sciatic pain; abdominal muscle strength, body mass index, and smoking did not; and back muscle strength was associated only retrospectively.

Riihimaki, H.; Wickstrom, G.; Hanninen, K.; Mattsson, T.; Waris, P.; Zitting, A. Radiographically detectable lumbar degenerative changes as risk indicators of back pain. A cross-sectional epidemiologic study of concrete reinforcement workers and house painters. *Scandinavian Journal of Work, Environment & Health*. 1989; 15(4): 280-85.

The association between radiographically detectable degenerative changes in the lumbar spine and back symptoms was studied, along with the possible effect of occupational work load. The subjects were 216 concrete reinforcement workers and 201 house painters. A questionnaire provided information on work history and earlier back accidents, and a standardized interview produced data on back symptoms. The occurrence of disc space narrowing, anterior and posterior spondylophytes, and end-plate sclerosis was recorded separately for each intervertebral space from lateral lumbar radiographs. Moderate to severe degenerative changes were associated with increased risk of sciatic pain but not with the occurrence of lumbago or nonspecific back pain. The different types of degenerative changes provided no further information. In a multivariate logistic regression analysis degenerative changes and earlier back accidents were significant independent predictors of sciatic pain. When these two variates were allowed for, the effect of occupation was not significant.

Wickstrom, G.; Hanninen, K. Determination of sciatica in epidemiologic research. *Spine*. 1987; 12(7): 692-98.

The international classification of diseases is unsuitable for epidemiologic research on the etiology of degenerative back disease. In cross-sectional studies of occupationally active populations, the occurrence of various symptoms and signs of back disease may be established. However, recommendations as to what data to gather or how to combine it into meaningful entities are not yet established. To validate reported sciatic pain by clinical findings, 252 reinforcement workers and 231 painters, all men, 20-64 years of age, were examined by nine tests. In the reinforcement workers exposed to heavy occupational loads the reports of sciatica during the previous month were clearly related to several clinical findings. The tests for restriction and pain on bending forward and sideward gave sensitivity values of 0.36-0.61 and specificity values of 0.82-0.87. Combining the results of the separate tests into pairs enhanced the

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sensitivity to 0.62-0.68, but reduced the specificity to 0.77-0.78. Referring to the current results, recommendations include a structured inquiry into sciatic pain during the previous month, backed up by clinical tests for range of and pain on lumbar movement, when studying the occurrence of back syndromes in physically heavy trades.

Wickstrom, G.; Hanninen, K.; Mattsson, T.; Niskanen, T.; Riihimaki, H.; Waris, P.; Zitting, A. Knee degeneration in concrete reinforcement workers. *British Journal of Industrial Medicine*. 1983; 40(2): 216-19.

The loads on the knees in concrete reinforcement work and maintenance painting were analysed on eight construction work sites. A total of 352 reinforcement workers and 231 painters. Finnish men aged 20-64, were clinically and radiologically examined to determine the condition of the knee joints in active workers. The loads on the knees and the occurrence of minor injuries and accidents were higher in reinforcement work than in painting, but the occurrence of symptoms, clinical signs, and radiological findings was equally common in both groups. Reinforcement work seemed to provoke more symptoms from degenerated knees than painting.

Wickstrom, G.; Niskanen, T.; Riihimaki, H. Strain on the back in concrete reinforcement work. *British Journal of Industrial Medicine*. 1985; 42(4): 233-39.

To investigate the long term effect of heavy construction work on the back the occurrence of postures, lifting, carrying, and accidents in concrete reinforcement work and in maintenance house painting were measured. The 32,620 observations covering 272 work hours showed that reinforcement work necessitated stooped postures and heavy lifting more often than did painting. Reported minor back accidents were more than ten times as common in reinforcement work than in painting (1.3 compared with 0.11 accidents per man-year, p less than 0.001). Accidents of the musculoskeletal system, registered by the insurance companies, were also several times more common in reinforcement work (81 compared with 25 per 1000 man-years, p less than 0.001). The premature development of lumbar degeneration detected in the clinical study of the reinforcement workers was evidently due to the occupational strain on the back. The different types of hazardous back loads probably potentiate the effects of each other.

PERIPHERAL NERVE ENTRAPMENT SYNDROMES

Feldman, R.; Goldman, R.; Keyserling, W. Classical syndromes in occupational medicine. Peripheral nerve entrapment syndromes and ergonomic factors. *American Journal of Industrial Medicine*. 1983; 4(5): 661-81.

Peripheral nerves are often mechanically damaged as a result of occupational hazards. The gradual development of symptoms and signs of peripheral nerve dysfunction can be overlooked in a worker until impaired function affects productivity and safety. Repeated mechanical injury resulting from external forces, as when holding a tool in a certain manner or maintaining a body part in a particular position for long periods of time, may cause subacute and chronic syndromes of nerve dysfunction. Compression of a nerve within a ligamentous-bony canal, stretching and subsequent ischemic injury by the squeezing of a nerve between muscle edges during repetitive motions are mechanisms for injury. Changes in the design of the workstation, modifications in the design of hand-operated tools, or adaptations in work procedures may prevent further

PIPEFITTING

damage and permit recovery.

Szabo, R.; Gelberman, R. The pathophysiology of nerve entrapment syndromes. *Journal of Hand Surgery* 1987; 12A (Part 2): 880-84.

Note: Abstract from authors' text.

Peripheral nerves are composed of sensory, motor, and sympathetic fibers surrounded by three consecutive tissue coats. The connective tissue coats protect the nerves from a variety of externally applied deforming forces. Experimental studies in our laboratory were designed to determine the relative significance of ischemia and mechanical deformation in early peripheral nerve compression, the critical threshold pressure of peripheral nerve conduction, and the clinical sensibility testing system most appropriate for evaluation and follow-up of patients with acute and chronic compressive neuropathies. Carpal tunnel pressures are elevated in patients with carpal tunnel syndrome, and these pressures are affected by wrist position. We know from present investigations that the peripheral nerve has an acute critical threshold pressure. Further studies need to be performed to answer the question, "can occupational activities elevate carpal tunnel pressures to a point that over an extended period of time will cause a carpal tunnel syndrome?"

PIPEFITTING

Ritz, B.; Brunnholz, K. Knee-joint lesions of pipe-fitters and welders employed by the public water and gas works. C. Hogstedt; C. Reuterwall (Eds.). *Progress in Occupational Epidemiology: Proceedings of the Sixth International Symposium on Epidemiology in Occupational Health*, Stockholm, Sweden, 16-19 August 1988. Amsterdam: Elsevier Science Publishers B.V.; 1988: 227-30.

A study examining to what extent pipefitting and welding are harmful for the knees of workers. These jobs include similar stresses for the knee-joints and the study focuses on the exposure time necessary to increase the risk for knee disorders. Pipefitters and welders working 11 to 15 years had a 3.5 and 3.3 (respectively) times higher risk for less specific knee-joint lesions and a 4.4 times higher risk for meniscus lesions compared to the unexposed group. The risks were lowest for those working less than 10 years and decreases again after 15 years, indicating a possible healthy worker effect. The results of the study show that the work of pipe-fitters and welders contains a high risk for knee-joint lesions.

PLUMBING WORK

Wickstrom, G. Prevention of occupational back disorders - an intervention study. *Scandinavian Journal of Work, Environment & Health*. 1988; 14(Suppl 1): 116-17.

Note: NIOSH Abstract.

An intervention study carried out in Finland for prevention of occupational back disorders was described. The study attempted to address all possible risk factors except psychosocial factors. Three occupations in one company and two in another were studied in order to obtain large groups with homogeneous exposure to back loads. Only male workers aged 35 to 44 were studied. In a shipyard, work planners, welders, and plumbers were studied; planners and platers were studied in a factory that produced ventilation equipment for paper machines. Initial baseline values were determined for the incidence of low back disorders and for

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low back loads at work. Questionnaires, interviews, and physical tests were used for determining incidence of disorders, and annual workdays lost were calculated for each of 2 years based on occupation, sex, and age. Physical and psychological low back loads were determined using video taping, electromyography, and questionnaires. Only some baseline results had been analyzed so far for planning of interventions. Company personnel were included in determinations of which risks to approach and how to act on them. Some practical measures had already been put into effect. Future plans for the study following completion of the intervention phase included a 3 year followup of company absenteeism registers, questionnaires measuring occurrence of symptoms, and measurement of back loads to detect any changes.

ROCKBLASTING

Stenlund, B.; Goldie, I.; Hagberg, M.; Hogstedt, C.; Marions, O. Radiographic osteoarthritis in the acromioclavicular joint resulting from manual work or exposure to vibration. *British Journal of Industrial Medicine*. 1992; 49(8): 588-93. The hypothesis that manual work and exposure to vibration are antecedents to the development of osteoarthritis was assessed employing a cross sectional study design. The frequency of osteoarthritis in the acromioclavicular joint was studied in three groups of workers in the construction industry. Two groups were manual workers (54 bricklayers and 55 rock blasters); the third group consisted of 98 foremen. The radiographic appearance of the right and left acromioclavicular joints was classified into one of five grades of osteoarthritis. A protocol was developed to assess exposure on the basis of job title, years of manual work, total weight lifted during working life, and total hours of exposure to vibrating tools. Odds ratios for job titles (manual worker v foreman) and for years of manual work as indicators of exposure were of similar magnitude of around 2.5. Construction workers who had lifted more than 709 tonnes had an increased risk of developing severe osteoarthritis of the right acromioclavicular joint, odds ratio: 2.62 (95% confidence interval (95% CI), 1.13-6.06). The odds ratio for the left side was 7.67 (95% CI, 2.76-21.34). In the analysis of vibration exposure, workers who had been highly exposed to vibration had an odds ratio of 1.99 (95% CI, 1.00-3.92) on the right side and 2.20 (95% CI, 1.07-4.56) on the left. This effect almost disappeared after simultaneous adjustment for manual work. Occupational and ergonomic factors, such as the sum of lifted tonnes during working life, job title, and the sum of years of manual work seem to be risk factors for osteoarthritis of the acromioclavicular joint, whereas vibration alone was a weaker risk factor.

Stenlund, B.; Goldie, I.; Hagberg, M.; Hogstedt, C. Shoulder tendinitis and its relation to heavy manual work and exposure to vibration. *Scandinavian Journal of Work Environment & Health*. 1993; 19: 43-49.

Three categories of construction industry workers (54 bricklayers, 55 rockblasters, and 98 foremen) were compared in a cross-sectional study. In a structured interview they reported exposure to loads lifted, vibration, and years of manual work. They were also subjected to a clinical investigation including medical history and a detailed shoulder examination. Among the rockblasters 33% had signs of tendinitis in the left and 40% in the right shoulder. Among the bricklayers and foremen 8-17% had signs of shoulder tendinitis. In a multiple logistic regression being a rockblaster compared with being a foreman showed an odds ratio (OR) of 3.33 for left-sided and 1.71 for right-sided shoulder

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tendinitis. Vibration exposure yielded an OR of 1.84 and 1.66 for the left and right sides, respectively. Vibration exposure or work as a rockblaster seemed to be risk indicators for tendinitis of the shoulders.

ROOFING WORK

Gustafsson, U.; Wimmell, L. An ergonomic study of rooflayers. *Bygghalsan Bulletin*. 1984-09-01.

Note: English Abstract.

An abstract of a study examining the application of roofing felt. The development of working methods in this sector has been practically stationary compared with other occupational categories in the building sector. Much unnecessary materials handling could be avoided if the materials were better placed and if cranes and barrows were better utilized. No aids have been produced for carrying and laying insulation slabs, but the development of laminated slabs for roof insulation constitutes a marked improvement in the possibilities available for working in ergonomically correct postures. In applying roofing felt, the one-man work method gives rise to considerably higher loads on the back and hips than the two-man work method.

Personick, M. Profiles in safety and health: roofing and sheet metal work. *Monthly Labor Review*. 1990; 113: 27-32.

Although falls are the leading cause of roofing injuries, accident prevention efforts must go beyond just reducing fall hazards. Even with adequate protection from falls in place, roofing industry workers would continue to face the potential hazards of material handling and other tasks commonly associated with construction, such as strenuous manual work performed under variable weather conditions and, often against tight timetables. Data from the Supplementary Data System of the Bureau of Labor Statistics indicate that the back and other portions of the trunk (abdomen, shoulder, and so forth) were the major parts of the body affected by injuries and illnesses. Three-tenths of the roofing cases involved portions of the trunk, primarily taking the form of back sprains. Overexertion (commonly resulting in sprains and strains from lifting objects) ranked second among major accident types, accounting for almost one-fourth of the roofing injury case total. Structural metal and other metal items were the leading sources of sheet-metal worker injuries, constituting three-tenths of that occupation's case total.

Vink, P. Application problems of a biomechanical model in improving roofwork. *Applied Ergonomics*. 1992; 23(3): 177-80.

The compression force during traditional roofwork and improved roofwork was calculated by means of a two-dimensional static biomechanical model. The improvement resulted in a 30% reduction in compression force, but also influenced factors which cannot be incorporated into the model but may cause back injuries. The frequency and velocity of movements were reduced and the trunk torsion increased. It is recommended that in further development this trunk torsion should be avoided. For valid application of biomechanical models in ergonomics, further research is needed. Priority should be given to epidemiologic research to establish the influence of compression force, trunk torsion and latero-flexion, frequency and velocity of movement on the development of lumbar injuries.

SCAFFOLD ERECTION

SCAFFOLD ERECTION

Kling, H. Erecting scaffolding. Bygghalsan Bulletin. 1984-09- 01.

Note: English Abstract.

An abstract of work showing the ergonomic problems of erecting scaffolding and a possible new design for scaffolding. Statistics show that scaffolding erectors constitute the occupational group which suffers the most from load afflictions in the construction sector. Their work is highly strenuous. Scaffolding erectors have the lowest average age within the sector, indicating that they seek other, less strenuous work as they grow older.

SHEET METAL WORK

Bygghalsan Stockholm Region 1990. A health and environmental survey of sheet metal workers. Bygghalsan Bulletin. 1991-09-16.

Note: English Abstract.

An abstract of a survey of the sheet metal industry (460 workers from 70 different companies) showing a high percentage of time spent in awkward postures. 83% of sheet metal workers spend 1-4 hours a day kneeling. Bent double and gently leaning forward are also very common when working at a bench. Sheet metal workers who spend more than one hour kneeling run twice the risk of suffering with knee problems as other workers who spend less time kneeling. If a worker spends more than an hour bent double, he is 1.5 times more at risk of suffering with back problems than otherwise, and if he works more than four hours in this position the risk increases by 3.6 times. 59% of the examined group of sheet workers stated that they were currently suffering with an illness/problems. One third suffered from back problems, 26% with knee problems, and 13% with shoulder problems. Tool design was identified as a particular problem, since certain types of hand tools, when used frequently, were associated with increased risk of wrist disorders.

Ekstrom, H.; Engholm, I.; Nyqerst, B.; Wallenquist, A. The kneeling working posture -- a stepchild in ergonomic research. Bygghalsan Bulletin. 1981-07-01.

Note: English Abstract.

An abstract on solutions to the problem of the kneeling posture among carpet layers and sheet metal workers. The anatomy of the knee joint is poorly constructed for protracted strain in the kneeling position. The authors investigated the prevalence of knee symptoms in different trades in the Swedish building industry and found it to be closely related to the amount of work in the kneeling posture. After examining different materials used in knee protectors, the authors found much of the equipment available on the market for knee protection to be unsuitable due to inappropriate materials and faulty design. They then consider design solutions for a satisfactory knee protector.

Personick, M. Profiles in safety and health: roofing and sheet metal work. Monthly Labor Review. 1990; 113: 27-32.

Although falls are the leading cause of roofing injuries, accident prevention efforts must go beyond just reducing fall hazards. Even with adequate protection from falls in place, roofing industry workers would continue to face the potential hazards of material handling and other tasks commonly associated with

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construction, such as strenuous manual work performed under variable weather conditions and, often against tight timetables. Data from the Supplementary Data System of the Bureau of Labor Statistics indicate that the back and other portions of the trunk (abdomen, shoulder, and so forth) were the major parts of the body affected by injuries and illnesses. Three-tenths of the roofing cases involved portions of the trunk, primarily taking the form of back sprains. Overexertion (commonly resulting in sprains and strains from lifting objects) ranked second among major accident types, accounting for almost one-fourth of the roofing injury case total. Structural metal and other metal items were the leading sources of sheet-metal worker injuries, constituting three-tenths of that occupations case total.

Raask, K. Working environment problems among building sheet-metal workers.

Bygghalsan Bulletin. 1980-05-01.

Note: English Abstract.

An abstract of a study of ergonomic problems encountered by sheet-metal workers. Since sheet-metal workers often work in unsuitable working postures, the training of sheet-metal workers must be improved. The workers must be given practical and theoretical knowledge concerning suitable work postures and the use of proper equipment.

Welch, L.; Hunting, K.; Kellogg, J. Carpal tunnel syndrome and work-related musculoskeletal symptoms among sheet metal workers -- report of a pilot study. (Submitted for publication).

We report results of two small studies of the relationship between musculoskeletal disorders and work tasks in sheet metal workers. Telephone interviews were conducted with 26 disabled sheet metal workers, and self-administered questionnaires were completed by 47 active and retired sheet metal workers. Among the disabled workers, rotator cuff cases reported the greatest percent of time spent in the field (as opposed to the sheet metal shop) and hanging duct, an overhead task commonly carried out during field work. Carpal tunnel cases spent the most time in the shop, and reported more hand tool use than the rotator cuff cases. Among the active and retired workers, the proportion of time spent in the shop was strongly associated with hand symptoms; sheet metal workers who spent at least 65% of their time in the shop had an odds ratio of 5.8 for symptomatic hand CTD ($p = 0.03$). The proportion of time spent hanging duct was strongly associated with both neck and shoulder symptoms; with odds ratios of 7.9 and 3.5, respectively.

SHIPYARD WORK

Berg, M.; Sanden, A.; Torell, G.; Jarvholm, B. Persistence of musculoskeletal symptoms: a longitudinal study. *Ergonomics*. 1988 Sep; 31(9): 1281-85.

The objective of this study was to determine whether or not symptoms from the musculoskeletal system disappear after retirement. The prevalence of symptoms among retired shipyard workers was compared with the prevalence among active manual workers and office workers, respectively. The study was based on 352 males, born between 1920 and 1935, who participated in health check-ups in 1982. Of the original group, 327 men were available for a second interview in 1985, of whom 85 manual workers and 38 office workers were laid off on a pension. Retired manual workers had about the same prevalence of symptoms in 1982 and 1985, indicating that musculoskeletal symptoms attributable to heavy

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physical work-load do not disappear within a time period of about three years. Active manual workers developed more symptoms between 1982 and 1985. Retired and active office workers had about the same prevalence of symptoms in 1982 and 1985.

Letz, R.; Cherniack, MG; Gerr, F.; Hershman, D.; Pace, P. A cross sectional epidemiological survey of shipyard workers exposed to hand-arm vibration. *British Journal of Industrial Medicine*. 1992; 49(1): 53-62. .
The hand-arm vibration syndrome, widely known as vibration white finger, is a disorder of nerves and blood vessels that occurs in workers exposed to segmental vibration. A cross sectional symptom survey was performed on a sample of workers employed by a large shipyard in the north eastern United States. Random samples were drawn from departments composed of full time dedicated pneumatic grinders, workers with part time exposure to vibration, and other workers not exposed to vibratory tools. Of the 375 workers sampled, 79% responded. The prevalence of white finger symptoms was 71%, 33%, and 6% among the three exposure groups respectively. Similarly, the prevalence of numbness and tingling in the hands and fingers in the three exposure groups was 84%, 50%, and 17%. Workers were classified according to the Stockholm Workshop staging systems for vascular and sensorineural symptom severity. Exposure-response analyses of both vascular and sensorineural stage showed monotonically increasing prevalence of higher disease stages with increasing duration of exposure. Logistic regression analysis, performed to control for potential confounding factors including age and current smoking state, produced highly significant (p less than 0.001) associations between cumulative duration of exposure and prevalence of symptoms. In these analyses smoking state was significantly related to vascular and sensorineural symptoms and age was not. Average latency to onset of symptoms was less than five years of full time equivalent work with vibratory tools. Logistic regression analyses were performed to assess the effect of use of particular work practices on reported symptoms. Further study of this workforce with objective, quantitative measures of peripheral neurological and vascular function is required to characterise the clinical and subclinical effects of vibration exposure.

Lindberg, H.; Danielsson, L. The relation between labor and coxarthrosis. *Clinical Orthopaedics & Related Research*. 1984; 191: 159-61.
Three hundred thirty-two laborers in a shipyard, all of whom had been working for decades in heavy industry, were compared with regard to the occurrence of coxarthrosis with a similar sized group of white-collar workers and with a random population sample. All three sets of men were of the same age. About one-fourth (the same in all three groups) had been referred for a hip roentgenographic examination at some time over the previous decades. In the group of laborers and their white-collar controls, coxarthrosis occurred in about 3%, with no difference between the two samples. The occurrence was less, but not significantly less, in those men who had been randomly selected from the population.

Torell, G.; Sanden, A.; Jarvholm, B. Musculoskeletal disorders in shipyard workers. *Journal of the Society of Occupational Medicine*. 1988; 38(4): 109-12.
The primary hypothesis was that musculoskeletal disorders were much more common in older workers than in younger ones. A questionnaire was answered by 1565 shipyard workers at a health check-up. We also scrutinized diagnoses from the health centre at the shipyards. The work load of each occupation was independently estimated in three degrees, low, moderate and heavy. There was

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no obvious relation between musculoskeletal disorders and age. However, there was as expected a strong relationship between work load and symptoms or medical diagnoses. The data indicated no strong correlation between musculoskeletal disorders from different organs.

STREET PAVING

Berndsen, M. Appliances for paviours: an evaluation of purchase and use. *Ergonomics*. 1990; 33(3): 361-66.

The results are presented of a study to evaluate a subsidy scheme designed by the Ministry of Social Affairs and Employment in The Netherlands in 1986. Every paving company that bought a specified appliance in that year could receive an allowance of 50% of the costs. The aim of the research was to enlarge the knowledge of the use of appliances in practice and to pass this new knowledge on in leaflets for different target groups. We visited companies who had applied for a subsidy as well as companies who had not done so. Employers and employees were interviewed and the use of appliances was observed in practice. We investigated economic aspects, quality aspects and the effect on the working conditions of various appliances. It was proved that some appliances can have a positive effect on the physical workload by eliminating tasks such as carrying and lifting heavy materials. Some important prejudices and barriers that impede the purchase and use of appliances were established. The study also showed some advantages and disadvantages of a subsidy scheme as a tool for marketing ergonomics.

TRAINING AND ERGONOMICS

Alvarez, E.; Carrillo, M.; Asfour, S.; Kang, K. The occupational biomechanics trainer: a computerized educational tool. S. Asfour. *Trends in Ergonomics/Human Factors IV: Proceedings of the Annual International Industrial Ergonomics and Safety Conference, Miami, Florida 9-12 June, 1987*. Amsterdam: Elsevier Science Publishers B.V.; 1987: 893-900.

Note: NIOSH Abstract.

A computer program was designed to help workers understand the tremendous force exerted on the lower back region of their bodies when they are in the act of lifting. It was hoped that once workers understood the biomechanics involved in the lifting process, they would take the necessary care to perform such tasks safely. The Occupational Biomechanics Trainer (OBT) was a menu driven program written in BASIC and operable with most microcomputers compatible with the IBM personal computer. The first section of the program contained a series of illustrations depicting principles of statics, anatomy, and biomechanics. The second section of the program consisted of a simulated biomechanical model which was used to determine the forces placed on the spine, given the user's body weight and the height and weight of the load being moved. A thorough description of the program and its operation were included. The authors conclude that this program offers a new, convenient, and easy method for training workers ranging from health care specialists to construction workers. The authors hope that the OBT will reinforce what workers have already been taught and encourage them to use proper lifting methods on the job. The final outcome could be a reduction in injuries, which results in a reduction of expenses to the

TRAINING AND ERGONOMICS

employer and suffering for the worker.

Construction Safety Association of Ontario and Bygghalsan of Sweden.

Stand/Lift/Carry. Toronto, Ontario: Construction Safety Association of Ontario; 1986.

A guide to proper lifting and carrying practices for the construction industry. Construction today still involves work that puts physical stress on the body. Various studies have shown that the construction trades have a higher incidence of locomotory disorders than many other occupations. A Swedish study of construction apprentices found that 18% had back problems when they began their training. This figure rose to 40% by the end of the second year. Pain in the back and joints is a predominant factor in forced retirement from the construction trades and in workers seeking less demanding occupations. Such changes are often accompanied by a serious reduction in living standard. In Canada as in Sweden, nearly 25% of the lost-time injuries in construction have their origin in the back. Indeed, it is estimated that 80% of the population will experience low back pain at some point in their working lives. In construction, about half of the back injuries result from lifting excessive weights or lifting incorrectly while roughly 23% are the result of slips, trips or falls.

Genaidy, A.; Karwowski, W.; Guo, L.; Hidalgo, J.; Garbutt, G. Physical training: a tool for increasing work tolerance limits of employees engaged in manual handling tasks. *Ergonomics*. 1992; 35(9): 1081-102.

The lack of physical fitness is a contributing factor to the etiology of musculoskeletal disorders resulting from the manual handling of material in industry. Thus the major objectives of this paper were (1) to discuss the role of physical fitness in the control of occupational injuries; (2) to review techniques available in the exercise physiology literature for increasing human physical capacity in industry; and (3) to review and evaluate studies on the effects of physical training on individuals engaged in manual handling tasks.

Genaidy, A. A training programme to improve human physical capability for manual handling jobs. *Ergonomics*. 1991 Jan; 34(1): 1-11.

The primary objectives of this study were to test whether the muscular endurance, muscular strength, cardiovascular endurance, and workload perception of individuals engaged in combined manual handling tasks could be improved through a short and intensive physical training programme. Two separate experiments were conducted to achieve the objectives of this study. The independent variables studied in each experiment were group type (training and control) and training session. Twenty male subjects participated in these experiments. The task performed in the first experiment was a combined lifting, lowering, pushing, pulling, and carrying activity. The second experiment featured an upper extremity manual handling task. Results indicated that, for both experiments, endurance time increased and heart rate decreased significantly during the course of training. For experiment 1, there were no significant changes in either static or dynamic strength with training. On the other hand, significant increases in static and dynamic strength were observed with the training group of experiment 2. The results of this study suggest that it is possible to improve muscular endurance and cardiovascular endurance with a short and intensive training programme. Moreover, an endurance training programme may increase both static and dynamic strength only if the weight of load handled during the training programme taxes the subject to 50% or more of his/her initial dynamic strength.

UPPER EXTREMITY MUSCULOSKELETAL DISORDERS

Nordin, M.; Crites-Battie, M.; Pope, M.; Snook, S. Education and Training. M. Pope, G. Andersson, J. Frymoyer, & D. Chaffin (Eds). Occupational Low Back Pain: Assessment, Treatment and Prevention. St. Louis, Missouri: Mosby Year Book; 1991: 266-76.

Note: NIOSH Abstract.

Education and training as techniques for preventing low back pain (LPB) were reviewed and discussed. Programs that attempt to reduce the incidence of and to prevent LBP have been developed. They have included instruction in safe lifting techniques, strength and fitness training, and back schools. Because lifting has been the most common event associated with the onset of compensable LBP, industries have made major efforts to train workers to lift safely; however, the effectiveness of the programs has been controversial. NIOSH has noted that many safe lifting programs rely on a dogmatic style of instruction with sets of rules that when followed literally can result in unsafe lifting practices. The effects of safe lifting training on reducing LPB have not been adequately studied. Extant studies indicated that the programs have achieved inconsistent results. Although it was not claimed that physical fitness training prevents LBP, it was noted that workplace fitness programs do have overall health benefits. Industrial back schools, a fairly recent development, focused on topics such as how the back functions, biomechanically sound lifting techniques, and maintaining good psychological and physical health. Studies of the ability of back schools to prevent LBP have produced conflicting results. The overall cost of the schools was less than the cost of providing physical therapy. Secondary approaches were based on minimizing disability by training management personnel and health practitioners to recognize the risk of LBP, and teaching LBP patients that management of the disorder and recovery is as much their responsibility as it is the medical practitioner's.

Tomer, G.; Olson, C.; Lepore, B. Back injury prevention training makes dollars and sense. National Safety News. 1984; January: 36- 39.

An article describing the success of a back injury prevention program that saved six dollars for every dollar spent on the program.

Workplace Health and Safety Agency. Musculoskeletal Injuries Prevention Program. Toronto, Ontario: Workplace Health and Safety Agency; 1992.

A training program that teaches workers and supervisors to identify and correct conditions that threaten to produce musculoskeletal injuries. Materials consist of a participant's manual and a leader's guide.

UPPER EXTREMITY MUSCULOSKELETAL DISORDERS

Armstrong, T. Ergonomics and cumulative trauma disorders. Hand Clinics. 1986; 2(3): 553-65.

Chronic tendon and nerve disorders of the upper extremity, such as tendinitis and carpal tunnel syndrome, are a common problem among persons who routinely perform hand-intensive work. This article summarizes the most commonly reported occupational risk factors: repetitiveness, forcefulness, certain postures, mechanical stresses, exposure to vibration, and exposure to low temperatures. It describes how to look for these factors and how to control them through the design of work equipment and procedures.

Armstrong, T.; Fine, L.; Goldstein, S.; Lifshitz, Y.; Silverstein, B. Ergonomics

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considerations in hand and wrist tendinitis. *Journal of Hand Surgery - St Louis*. 1987; 12(5 Pt 2): 830-7.

The objectives of this article are to present (1) a historical perspective on hand and wrist tendinitis in workers, (2) new data that demonstrate a relationship between the repetitiveness and forcefulness of manual work and the prevalence of tendinitis, (3) possible biomechanical factors in tendinitis, and (4) possible job modifications for the prevention of tendinitis. Numerous studies during the last 100 years show that tendinitis is a major cause of worker suffering and workers' compensation in intensive hand work. Epidemiologic data show that the risk of hand and wrist tendinitis in persons who perform highly repetitive and forceful jobs is 29 times greater than in persons who perform jobs that are low in repetitiveness and force. A possible factor in this relationship is viscous deformation of the tendons and adjacent tissues. Although these data suggest that the risk of tendinitis among workers can be reduced by reduction of the repetitiveness and the forcefulness of the work, this hypothesis has not yet been fully tested.

Fine, L.; Silverstein, B.; Armstrong, T.; Anderson, C.; Sugano, D. Detection of cumulative trauma disorders of upper extremities in the workplace. *Journal of Occupational Medicine*. 1986; 28(8): 674-78.

Surveillance for musculoskeletal disorders of the upper extremity in industry is in its infancy. Research efforts to elucidate the causal factors of these disorders often rely on either the analysis of existing medical records, worker compensation records (passive surveillance), or the surveying of workers with questionnaire and physical examination (active surveillance). The use of either type of data for routine surveillance presents several difficulties illustrated with the results presented in this paper. The analysis of existing records is generally less costly but the reliability of the data is difficult to assess. Standardized questionnaire and physical examinations can be as sensitive as the use of unusually thorough existing occupational medical records; however, it is unclear whether the additional cost of an active surveillance system will deter the routine use of such systems.

Gerr, F.; Letz, R.; Landrigan, P. Upper-extremity musculoskeletal disorders of occupational origin. *Annual Review of Public Health*. 1991; 12: 543-66.

Sufficient evidence is available at this time to conclude that several well-defined soft-tissue disorders of the upper extremities are etiologically related to occupational factors. These disorders include tendinitis of the hand and wrist, CTS, and hand-arm vibration syndrome. Force, repetition, and vibration have been established as risk factors in the etiology of these disorders. Evidence exists that other, poorly understood factors also may contribute to etiology. At this time no firm guidelines can be established regarding maximum no-effect exposure levels. We agree, however, with Armstrong: "Although there are no standards for excessively repetitive or forceful work, common sense dictates that these tasks be minimized to the extent possible." Tool and job redesign may be required in many situations to accomplish these goals. In addition to appropriate reductions in risk factors, medical surveillance is required and will allow greater appreciation of the extent of this growing problem, as well as ongoing assessment of the efficacy of preventive intervention.

Kilbom, A. Intervention programmes for work-related neck and upper limb disorders: strategies and evaluation. *Ergonomics*. 1988 May; 31(5): 735-47.

In this review the design and results of controlled interventions against work-related neck and upper limb disorders are discussed. The method of intervention

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-- workstation redesign, work reorganization, worker training and education -- is related to the outcome. The results should be evaluated using a range of intermediate and end-point variables. Very little attention has yet been paid to the cost effectiveness of interventions and unsuccessful interventions are seldom reported, which makes an evaluation of the 'most successful design' incomplete. The use of reference groups for control of background variables, like fluctuations in work output and staff turnover is emphasized. The role of researchers, as active interveners or as passive recorders of effects is discussed, and the importance of an active contribution from management and employers is stressed.

Stock, S. Workplace ergonomic factors and the development of musculoskeletal disorders of the neck and upper limbs: a meta-analysis. *American Journal of Industrial Medicine*. 1991; 19(1): 87-107.

In the past 10 years there has been growing awareness among occupational health professionals worldwide of the large burden of illness associated with musculoskeletal disorders of the neck and upper limbs. It has been suggested that these disorders are associated with highly repetitive work and are due, at least in part, to ergonomic factors. This review examines the epidemiologic evidence of the relationship between workplace ergonomic factors such as repetition, force, static muscle loading, and extreme joint position and the development of muscle, tendon, and nerve entrapment disorders of the neck and upper limbs of exposed workers. An extensive search for relevant studies was undertaken. Of 54 potentially relevant studies identified, three met the a priori inclusion criteria. The validity of these studies was assessed, and one study was found to have major flaws. Criteria to demonstrate causality were also applied and were met in the most rigorously conducted study. When the results of these studies are compared and aggregated where appropriate, they provide strong evidence of a causal relationship between repetitive, forceful work and the development of musculoskeletal disorders of the tendons and tendon sheaths in the hands and wrists and nerve entrapment of the median nerve at the carpal tunnel. The comparison of exposed to controls for hand/wrist tendinitis gives an unadjusted common odds ratio of 9.1 (95% CI 4.9-16.2). The adjusted odds ratio for carpal tunnel syndrome is 15.5 (95% CI 1.7-141.5) based on the most rigorous study.

Wallace, M.; Buckle, P. Ergonomic aspects of neck and upper limb disorders. *International Reviews of Ergonomics*. 1987; 1: 173-200.

This review paper considers the nature of the problem of neck and upper limb disorders with respect to the diagnoses and classification of classic musculoskeletal disorders and those which are less well defined. In particular it examines the collective terms which have arisen in recent years. Methodological difficulties in undertaking epidemiological studies of these disorders are described with reference to a number of investigations. The paper argues that at present there is a lack of theory linking specific health effects to specific causal factors, and considers the evidence for associated risk factors. Links with occupation, posture, movement and force, task dimensions, work content and psychological factors are discussed with reference to the current literature. The role of individual characteristics and the use of screening tests is similarly reviewed. The paper continues by examining the results of a number of intervention studies and examines their effectiveness. The conclusions emphasize the importance of static load and constrained postures as associated risk factors and, in addition, identify a number of areas for future research.

VIBRATION EXPOSURE

VIBRATION EXPOSURE

Carlsoo, S. The effect of vibration on the skeleton, joints and muscles: a review of the literature. *Applied Ergonomics*. 1982; 13(4): 251-58.

Owing to the elasticity and plasticity of the skeleton, joints and muscles, the musculoskeletal system is capable of absorbing and damping mechanical vibration without damage as long as the vibration level is within tolerable limits. However, technical developments have led to the exposure of many people to intolerable variation levels with destructive changes as a result. These injuries to the musculoskeletal system continue to be the subject of research interest. Initially, the joints and joint complaints attracted the greatest attention. Vibration damping takes place mainly in the joints. The incidence of destructive joint changes has been examined in comprehensive clinical, epidemiological and radiographic studies, mainly concentrating on the joints of the hand and arm. The response of muscles to vibration is often expressed in the form of a tonic vibration reflex (TVR) which arises as a result of stimulation of the muscle spindles and therefore resembles the classic tonic stretch reflex. There is increased muscular activation for stabilisation of the joint positions, especially during whole-body vibration. Studies have also disclosed how vibration affects body equilibrium and equilibrium control and how vibration can elicit muscle pain, cramps and reduced muscular strength.

Wilder, D. The biomechanics of vibration and low back pain. *American Journal of Industrial Medicine*. 1993; 23(4): 577-88.

This work is a review of the mechanical factors related to low back pain production in a vibration environment. The sitting posture is an extreme orientation for the lumbar intervertebral disc that 1) increases its internal pressure, 2) increases its anteroposterior shear flexibility, while: 3) decreasing its resistance to buckling instability and 4) stressing the posterior region of the disc. Vibration is an additional mechanical stressor. Several studies suggest that the following preventive measures be taken to reduce the risk of low back pain due to driving: 1) minimize the vibration reaching the driver, 2) avoid lifting or bending immediately following driving, and 3) walk around for a few minutes following driving.

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Bovenzi, M.; Fiorito, A.; Volpe, C. Bone and joint disorders in the upper extremities of chipping and grinding operators. *International Archives of Occupational & Environmental Health*. 1987; 59(2): 189-98.

X-ray examinations of the wrists, the elbows and the shoulders were carried out on 67 vibration-exposed foundry workers and on 46 comparable referents performing heavy manual work. Both groups had a mean age of 39.6 years. Musculoskeletal symptoms, such as arthralgias of the wrist and elbow joints, muscle pain and decreased muscular force, were found to be significantly increased in the chipping and grinding workers compared with the referents. After adjustment for age, the prevalence of cysts in the metacarpal and carpal bones was almost the same in the two groups, whereas radiological signs of osteoarthritis in the wrist joint were more frequent among the vibration-exposed workers (P less than 0.025). The overall prevalence of radiographic abnormalities

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in the elbow joint was higher in the vibration group than in the reference group (P less than 0.025). Olecranon spurs were observed in 50.7% of the exposed operators and in 28.2% of the referents (P less than 0.025). No difference in the prevalence of radiological changes in the shoulder could be demonstrated between the populations studied. In both groups injuries of bones and joints were not associated with age. Among the chipping and grinding operators, a slight but not significant trend in the prevalence of skeletal abnormalities with increasing vibration exposure was observed. The results of this study indicate that the foundry workers using vibrating tools were affected with bone and joint disorders in the elbow and, to a lesser extent, in the wrist, which occurred more frequently than was observed in unexposed referents, who performed solely heavy manual activity. Among the vibration-exposed workers, no relationship between radiological changes in the upper limbs and symptoms of vibration white finger was found, pointing out that different pathogenic mechanisms are involved.

Brismar, T.; Ekenvall, L. Nerve conduction in the hands of vibration exposed workers. *Electroencephalography & Clinical Neurophysiology*. 1992; 85(3): 173-76. Symptoms of peripheral neuropathy in the hands are common among workers using vibrating tools. The mechanism for this and its relation to carpal tunnel syndrome (CTS) was studied in workers exposed to vibration at their workplace (17), along with a control group of healthy construction workers with heavy manual work but without vibration exposure (10). Patients with uni- or bilateral CTS (11) and a group of healthy volunteers without manual work (9) were included for comparison. Median nerve conduction velocities were measured both over the carpal tunnel and in a more distal segment. Vibration exposed workers had similar conduction velocities to unexposed construction workers. The subgroup of vibration exposed patients with symptoms from the hands had normal conduction in the ulnar nerve but demonstrated a decrease in median nerve conduction comparable (but less pronounced) with the CTS group. On a group basis these results indicated that the median nerve is most vulnerable for hand-arm vibrations. However, the conduction defects were not pronounced enough to diagnose CTS in most individual cases.

Cherniack, M. Raynaud's phenomenon of occupational origin. *Archives of Internal Medicine*. 1990; 150(3): 519-22. Vibration delivered to the hand and arm by industrial pneumatic tools is a common cause of vascular and neurovascular problems, including cold-induced vascular spasm (vibration white finger) and peripheral neuropathies with paresthesias, dysesthesias, and sensory abnormalities. A decade ago, the US Public Health Service estimated that 1.2 million American workers were at risk. Differentiation of primary and secondary Raynaud's phenomenon from the thoracic outlet syndrome and from the carpal tunnel syndrome pose potential diagnostic difficulties. Despite growing public recognition of upper extremity problems caused by repetitive trauma, there have been few investigations of vibration-induced disorders in the United States. This is not true worldwide, particularly in Northern Europe, where there has been significant intervention in medical surveillance and tool design. There does appear to be, however, frequent misdiagnosis and misdirected surgery. This has particular significance for the clinician, since in the 1990s, cumulative trauma injuries are expected to exceed all other work-related injuries.

Cherniack, M.; Letz, R.; Gerr, F.; Brammer, A.; Pace, P. Detailed clinical assessment of neurological function in symptomatic shipyard workers. *British Journal of Industrial Medicine*. 1990; 47(8): 566-72.

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Forty eight patients with extensive occupational exposure to pneumatic grinding tools were evaluated at a university sponsored occupational health clinic. All patients were interviewed and examined by a physician and assessed neurologically with standard clinical, functional motor, quantitative vibrotactile, and electrodiagnostic tests. Sensorineural symptoms were nearly universal; 47 patients (98%) reported numbness and tingling of the hands and fingers. Among clinical tests, two point discrimination and 30 Hz vibration perception were most frequently abnormal. In order to evaluate associations between quantitative test results and sensorineural symptoms, patients were stratified into two groups of symptom severity according to a consensus sensorineural staging system. The tests that discriminated best between the groups of more and less symptomatic patients were hand strength dynamometry, and vibrotactile thresholds. Age standardised 120 Hz vibrotactile thresholds were significantly raised in digit II in 41% of hand measurements. Nerve conduction studies were neither significantly different between more and less symptomatic groups nor correlated with clinical and quantitative sensory tests. Twenty five per cent of the patients had slowing of sensory conduction velocities in the median nerve at the wrist (less than 48 m/s). Of this subset of patients only two showed abnormal slowing of the median nerve distal to the wrist, but half also showed ulnar nerve slowing (less than 47 m/s).

Letz, R.; Cherniack, MG; Gerr, F.; Hershman, D.; Pace, P. A cross sectional epidemiological survey of shipyard workers exposed to hand-arm vibration. *British Journal of Industrial Medicine*. 1992; 49(1): 53-62.

The hand-arm vibration syndrome, widely known as vibration white finger, is a disorder of nerves and blood vessels that occurs in workers exposed to segmental vibration. A cross sectional symptom survey was performed on a sample of workers employed by a large shipyard in the north eastern United States. Random samples were drawn from departments composed of full time dedicated pneumatic grinders, workers with part time exposure to vibration, and other workers not exposed to vibratory tools. Of the 375 workers sampled, 79% responded. The prevalence of white finger symptoms was 71%, 33%, and 6% among the three exposure groups respectively. Similarly, the prevalence of numbness and tingling in the hands and fingers in the three exposure groups was 84%, 50%, and 17%. Workers were classified according to the Stockholm Workshop staging systems for vascular and sensorineural symptom severity. Exposure-response analyses of both vascular and sensorineural stage showed monotonically increasing prevalence of higher disease stages with increasing duration of exposure. Logistic regression analysis, performed to control for potential confounding factors including age and current smoking state, produced highly significant (p less than 0.001) associations between cumulative duration of exposure and prevalence of symptoms. In these analyses smoking state was significantly related to vascular and sensorineural symptoms and age was not. Average latency to onset of symptoms was less than five years of full time equivalent work with vibratory tools. Logistic regression analyses were performed to assess the effect of use of particular work practices on reported symptoms. Further study of this workforce with objective, quantitative measures of peripheral neurological and vascular function is required to characterise the clinical and subclinical effects of vibration exposure.

Rohmert, W.; Wos, H.; Norlander, S.; Helbig, R. Effects of vibration on arm and shoulder muscles in three body postures. *European Journal of Applied Physiology & Occupational Physiology*. 1989; 59(4): 243-48.

The electromyographic responses of arm and shoulder muscles to vibrations were studied in three postures similar to the postures of drilling in a ceiling,

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drilling in a wall and drilling in a floor. This experiment was performed within the defined parameters of: vibrational frequency at 30 Hz, acceleration level 40 m.s⁻² (rms), pushing force expressed as percentage maximal voluntary contraction, and gripping force which was set at 100 N. The exposure time for each test was 5 min. The general findings from these three body postures show that all the examined muscles were affected by exposure to vibration. The EMG index increased as follows: trapezius muscle 39% (p less than 0.05), lower-arm flexor muscles 23% (p less than 0.05), infraspinatus muscle 14% (p less than 0.05), lower-arm extensor muscles 14% (p less than 0.1) and biceps muscle 6% (p less than 0.1). The muscle most affected by vibration was found to be the trapezius muscle. It should be taken into consideration that vibration can be a contributing factor in neck/shoulder disorders among power handtool operators. The general conclusion from this study is that changes in working posture give different transmissions of vibration in the upper extremities. It seems as if the prime movers and muscles with an increased muscle length or increased degree of contraction are most affected by vibration.

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Helmkamp, J.; Talbott, E.; Marsh, G. Whole body vibration--a critical review. *American Industrial Hygiene Association Journal*. 1984; 45(3): 162-7.

Whole body vibration is an environmental stressor to which a substantial portion of the American workforce has been exposed. Numerous experimental studies have examined the acute effects of exposure to WBV but only in the last decade have the chronic effects been addressed. However, to date, no comprehensive review has been conducted of this common occupational exposure. This paper critically reviews the existing literature and summarizes the known health effects. Experimental study results are generally inconsistent and dependent on the characteristics of the vibration exposure. NIOSH's epidemiological studies have shown that several disorders are more prevalent in some occupations [e.g., operators of heavy construction equipment]; however, causal relationships have not been established. Health professionals should be aware of potential ill effects that may result from exposure to WBV in combination with other environmental stressors.

Hulshof, C.; van Zanten, B. Whole-body vibration and low-back pain. A review of epidemiologic studies. *International Archives of Occupational & Environmental Health*. 1987; 59(3): 205-20.

This review presents a critical evaluation of the literature on health effects in long-term occupational exposure to whole-body vibration. To assess the relative weight of each epidemiologic study, a scoring procedure has been used, according to the quality of exposure data, effect data, study design and methodology. The most frequently reported adverse effects are: low-back pain, early degeneration of the lumbar spinal system and herniated lumbar disc. No study reached an adequate score on all criteria of evaluation. Nevertheless, because most studies show a strong tendency in a similar direction, it may be concluded that long-term exposure to whole-body vibration is harmful to the spinal system. The results do not yet permit firm conclusions on exposure-response relationships. Further epidemiologic research, particularly of high-risk groups, is needed.

Pope, M.; Hansson, T. Vibration of the spine and low back pain. *Clinical Orthopaedics*

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& Related Research. 1992; 279: 49-59.

There are now many studies suggesting a positive relationship between both low back pain and spinal degeneration and exposure to whole body vibration. Such relationships appear to be particularly marked in drivers of tractors, earth-moving equipment, and trucks. There is a tendency toward a greater incidence of complaints as exposure increases. Vibration affects the spine by exciting a 4-6-Hz resonance that is related to the biologic "soft spring" between S-1 and the seat. The muscle nerves fire sequentially under vibration and fatigue. In animals, vibration exposure leads to pronounced creep, increased disk pressure, and changes in the levels of neuropeptides in the dorsal root ganglia.

Seidel, H. Selected health risks caused by long-term, whole-body vibration. *American Journal of Industrial Medicine*. 1993; 23(4): 589-604.

The problem of a "vibration disease" caused by low-frequency whole-body vibration (wbv) is critically discussed. Disorders of the nervous, circulatory, and digestive systems are interpreted not to be predominantly wbv-specific, but to be related to the totality of working conditions. Long-term wbv exposure can probably contribute to the pathogenesis of disorders of female reproductive organs (menstrual disturbances, anomalies of position) and disturbances of pregnancy (abortions, stillbirths). Animal experiments suggest harmful effects on the fetus. WBV has a minor synergistic effect on the development of noise-induced hearing loss. Degenerative changes of the spine are more prevalent among wbv-exposed workers. Model calculations demonstrate an increased spinal load in pregnant women exposed to wbv or self-induced vibration, and illustrate a possibility for the comparison of data on stress, strain, and strength. The analysis of individual exposure-effect relationships is suggested as a future approach for evaluating potential occupation-related diseases.

Seidel, H.; Bluethner, R.; Hinz, B. Effects of sinusoidal whole-body vibration on the lumbar spine: the stress-strain relationship. *International Archives of Occupational & Environmental Health*. 1986; 57(3): 207-23.

The aim of this experimental study was to estimate the strain in the lumbar spine due to whole-body vibration (WBV). Four male subjects were exposed to vertical sinusoidal WBV with frequencies ranging from 1 to 15 Hz at two intensities ($I_1 = 1.5 \text{ ms}^{-2} \text{ rms}$; $I_2 = 3.0 \text{ ms}^{-2} \text{ rms}$). The compressive forces acting on the disc L3-4 during the extreme values of acceleration were predicted on the basis of anthropometric data, EMG of back muscles and the acceleration of the upper trunk, using a simple biomechanical model. The estimated mechanical activity of back muscles was not able to protect the spine under many exposure conditions. The highest compressive forces were predicted for WBV with 7.5, 8 and 4.5 Hz. The results suggest the possibility of fatigue failures at the endplates of lumbar vertebrae after intense long-term exposure to WBV.

Seidel, H.; Heide, R. Long-term effects of whole-body vibration: a critical survey of the literature. *International Archives of Occupational & Environmental Health*. 1986; 58(1): 1-26.

The relevant literature on the long-term effects of whole-body vibration (wbv) was analyzed in order to obtain condensed information concerning a possibly higher health risk due to long-term exposure, the relationships between the quality of exposure (intensity, duration, frequency) and pathological effects, the significance of individual factors, conclusions for standard setting, and medical health care of workers exposed to wbv. Vibration exposure was characterized by measured values in one third of papers, whereas more than 30% of the publications selected did not contain any exposure data. Health data of about

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43,000 workers exposed to wbv and 24,000 persons in control groups were reported. The results indicate an increased health risk of the spine and of the peripheral nervous system after intense long-term wbv. With a lower probability, the digestive system, the peripheral veins, the female reproductive organs, and the vestibular system were also affected. Long-term effects on other organs cannot be precluded. Wbv can worsen certain endogenous conditions. Specific diagnostic features of pathological changes induced by wbv with frequencies below 20 Hz do not exist. On average, the health risk increases with higher intensity or duration of exposure, however, quantitative exposure-effect relationships cannot be derived at present. Since wbv near the Exposure Limit of the International Standard IS 2631 is not completely safe, this survey provides arguments in favour of a lower limit. Contra-indications for professional exposure to wbv and further research needs are discussed.

- Seroussi, R.; Wilder, D.; Pope, M. Trunk muscle electromyography and whole body vibration. *Journal of Biomechanics*. 1989; 22(3): 219-29.
By measuring the electromyographic (EMG) activity of the paraspinal muscles, we have estimated the average and peak-to-peak torque imposed on the spine during whole body vibration. Six subjects had surface electrodes placed on their erector spinae muscles at the L3 level. The EMG-torque relationship was estimated by having each subject perform isometric horizontal pulls in an upright seated posture. The subject was then vibrated vertically and sinusoidally in a controlled, flexed, slightly lordotic seated posture, in 1 Hz increments from 3 to 10 Hz at a 0.1 g RMS seat acceleration level. Between vibration readings taken at each frequency, a static reading was also taken with the subject maintaining the same posture. The entire vibration-static 3-10 Hz test was repeated for reliability purposes. Specialized digital signal processing techniques were developed for the EMG signals to enhance the measured cyclic muscle activity and to allow automatic measurement of the time relationship between the mechanical displacement and the estimated torque. We found significantly more average and peak-to-peak estimated torque at almost all frequencies for vibration vs static sitting.
- Wilder, D.; Woodworth, B.; Frymoyer, J.; Pope, M. Vibration and the human spine. *Spine*. 1982; 7(3): 243-54.
Vibrational effects have been found to be associated with increased frequency of low-back pain in various industries, and because of this the study herein reported was conducted to assess the physiologic response of the spinal system to sinusoidal vibrations. A device replicating industrial vibration was constructed and employed on healthy human volunteers to determine the stiffness, impedance, and resonant characteristics of the subjects. Three peaks of enhanced transmissibility corresponding to the resonant frequency of the spinal system were found. The greatest transmissibility of vibratory input occurs at the first resonant frequency (5Hz) where marked enhancement of vibrational input occurs as vibrations pass through the spinal system. A progressive stiffening of the system occurs in response to vibrational inputs of increasing frequency. The effects of posture, the Valsalva maneuver, and fatigue alter the normal response. Structures vibrated at the first resonant frequency have greater potential for damage.
- Zimmerman, C.; Cook, T.; Goel, V. Effects of seated posture on erector spinae EMG activity during whole body vibration. *Ergonomics*. 1993; 36(6): 667-75.
The purpose of this study was to evaluate the electromyographic (EMG) response of the erector spinae to whole body vibration in three different

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unsupported seated postures: neutral upright, forward lean, and posterior lean. Subjects were 11 healthy college-age men. EMG was collected using bipolar surface electrodes placed bilaterally over the erector spinae at the L4 level. A modified chair with attached accelerometer was affixed to an induction type vibrator. Subjects were vibrated vertically at 4.5 Hz and 6.21 m.s.⁻² RMS. Data were collected in each of the three postures for 30 s pre- and post-vibration and for 2 min during vibration. Mean EMG values were determined for each sampling period and compared using ANOVA. The mean value for anterior lean was significantly larger ($p < 0.05$) than that for posterior lean and neutral. EMG data analysed by triggered averaging showed a phase-dependent response to the vibratory cycle for the forward leaning and neutral upright postures. The results of this study indicate that the magnitude of the vibration synchronous response of the erector spinae musculature is dependent upon body posture. This response may be an important factor in the onset of muscular fatigue and the increased incidence of back disorders among individuals exposed to whole body vibration.

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Armstrong, T.; Fine, L.; Radwin, R.; Silverstein, B. Ergonomics and the effects of vibration in hand-intensive work. *Scandinavian Journal of Work, Environment & Health*. 1987; 13(4): 286-89.

Along with ergonomic factors, such as forceful and repeated exertion and certain postures, vibration has been cited as a factor of chronic nerve and tendon disorders such as carpal tunnel syndrome and tendinitis. The arguments for the contribution of vibration come from epidemiologic studies, clinical case analyses, and studies of short-term effects. It is well established that vibration stimulates muscle contraction, which is called the tonic vibration reflex. It is also known that vibration reduces tactility and that tactility affects the amount of force exerted to hold or manipulate a given object. For localized vibration exposure of the hand and arm to occur, the hand must grip a vibrating object. Vibration may increase the risk of chronic tendon and nerve disorders by increasing the force exerted in repetitive manual tasks. This close relationship between force and vibration, and difficulties in measuring force and vibration in manual work, makes it very difficult to determine their relative contributions in epidemiologic and clinical studies.

Gemne, G.; Saraste, H. Bone and joint pathology in workers using hand-held vibrating tools. An overview. *Scandinavian Journal of Work, Environment & Health*. 1987; 13(4): 290-300.

A literature evaluation was made with regard to the radiological documentation of bone and joint pathology in the hands and arms of workers using vibrating tools. There is evidence that work with pneumatic percussive tools (such as chipping hammers and scalers) may cause premature elbow and wrist osteoarthritis, although of very low prevalence. This work-related disorder is not specific to vibration exposure. Instead, it is likely to result from the strong dynamic and static joint loading (often in extreme positions of the joint) and the repetitive hand-arm movements (sometimes also repeated minor traumatization) typical for tool manipulation in any heavy labor. Exposure to low-frequency percussion may, however, play a particular etiologic role: damage to the joint cartilage by repeated shocks from the tool, additional articular load (and consequent strain) associated with a vibration-induced increase in the need for joint stabilization and higher gripping forces, the tonic vibration reflex (which increases muscle contraction), and a stronger grip induced when tactile sensibility is diminished by vibration. So

VIBRATION IN TOOLS AND EQUIPMENT

far, no investigations have ventured into the great complexity of possible confounders and effect modifiers. A constitutional susceptibility may be required to produce osteoarthritis. The allegation that hand-arm vibration exposure causes an excess prevalence of bone cysts, vacuoles, Kienbock's disease, or pseudarthrosis of the scaphoid has not been validly documented. Exposure to vibration of higher frequencies (such as from rotating drills, grinders, and chain saws) does not seem to be associated with excess bone and joint pathology. - The observed large variation in the prevalence of skeletal disorders may be explained by biodynamic and ergonomic differences between various occupations.

Gonner, H. Noise and vibration reduction on construction machinery. *Ergonomics in Developing Countries: An International Symposium*; 1985; Jakarta, Indonesia. Geneva: International Labor Office; 1987; Occupational Safety & Health Series No. 58: 224-37.

Note: NIOSH Abstract.

A mobile test facility for analyzing the effectiveness of noise and vibration suppression devices on construction equipment was described. The facility was developed by the Tiefbau Berufsgenossenschaft (The Insurance Association for Occupational Safety and Health in Civil Engineering) (TBG), Munich, Federal Republic of Germany. The facility consisted of high grade instruments for recording noise and vibrations. The data were analyzed by a weighting network that was based on a digital 0.33 octave analyzer. The data were processed on a personal computer and the weighted results were displayed on a video display terminal. The system contained a backup diskette memory that stored the programs and data. The noise level recorder was linked to the analogue output of the octave analyzer. This feature made it possible to provide hard copy of the noise levels as a function of time and their frequency spectra. Examples of analyses performed by the TBG facility were provided. These included analyses of the effects of noise suppression techniques on a wheeled loader, a vibrating roller, a joint cutter, and an analysis of a method for reducing vibrations on a wheeled loader.

Jacobsson, B.; Nordstrom, B.; Lundstrom, R. Vibrating hand-held machines in the construction industry. *Safety Science*. 1992; 15: 367-73.

The aim of this study was to investigate and measure vibration levels of the most commonly used machines within the construction industry. In the report 186 hand-held machines divided into more than 15 different machine groups have been studied. The project is a joint venture between Bygghalsan (The Construction Industry's Organization for Working Environment, Safety & Health) and the National Institute of Occupational Health.

Miyashita, K.; Morioka, I.; Tanabe, T.; Iwata, H.; Takeda, S. Symptoms of construction workers exposed to whole body vibration and local vibration. *International Archives of Occupational & Environmental Health*. 1992; 64(5): 347-51.

To study the effects of construction machinery operation on subjective symptoms, a questionnaire survey was carried out among construction machinery operators by a self-reporting method. Subjects were 184 power shovel operators, 127 bulldozer operators, 44 forklift operators as operator groups, and 44 office workers as a control. Their ages were in a range of 30-49 years. The questionnaire contained 20 symptoms referring to fatigue, digestive problems, and upper or lower limbs or back problems. The prevalence rate and symptom characteristics were examined. The dominant symptoms of the operator groups were stiff shoulder, low back pain, and stomach symptoms. The prevalence rate

VIBRATION IN TOOLS AND EQUIPMENT

of low back pain was significantly different between forklift operators and controls. No significant differences were found in the symptoms of upper limbs and fingers between operator groups and controls. The prevalence of Raynaud's phenomenon was 0.5%-2.3% in the operator groups and 2.3% in the control group.

Musson, Y.; Burdorf, A.; van Drimmelen, D. Exposure to shock and vibration and symptoms in workers using impact power tools. *Annals of Occupational Hygiene*. 1989; 33(1): 85-96.

In The Netherlands damage to health due to occupational exposure to shock and vibration is seldom reported. A survey was therefore made of the nature, extent and severity of exposure to shock and vibration. This paper presents the results of an epidemiological study, by questionnaire, among workers using impact power tools. Data were collected about exposure time, symptoms and the subjective workload. A prevalence rate of 17% for symptoms of white finger was found. In the logistic regression symptoms of back pain showed an increased prevalence with increasing total time exposed to vibration. This study shows that exposure to vibration due to working with impact power tools, either alone or in combination with ergonomically bad working conditions, probably contributes to these symptoms. An estimate of the population at risk showed that over 30,000 workers in The Netherlands who use impact power tools are exposed to a vibration intensity of 10-40 m/s^2 . This intensity exceeds the standards advocated in draft standards in the U.K. (BSI, 1987) and U.S.A. (ACGIH, 1984). The results also provide evidence that in the Netherlands exposure to hand-arm vibration damages health. It is suggested that damage to health due to occupational exposure to vibration is underestimated by the Dutch occupational health services. It was concluded that more investigation is needed to evaluate the precise nature of occupational exposure to vibration in order to provide a basis for its reduction or elimination.

Radwin, R.; Armstrong, T.; Chaffin, D. Power hand tool vibration effects on grip exertions. *Ergonomics*. 1987; 30(5): 833-855.

Operation of vibrating power hand tools can result in excessive grip force, which may increase the risk of cumulative trauma disorders in the upper extremities. An experiment was performed to study grip force exerted by 14 subjects operating a simulated hand tool vibrating at 9.8 m/s^2 and 49 m/s^2 acceleration magnitudes, at 40 Hz and 160 Hz frequencies, with vibration delivered in three orthogonal directions, and with 1.5 kg and 3.0 kg load weights. Average grip force increased from 25.3 N without vibration to 32.1 N (27%) for vibration at 40 Hz, and to 27.1 N (7%) for vibration at 160 Hz. Average grip force also increased from 27.4 N at 9.8 m/s^2 acceleration to 31.8 N (16%) at 49 m/s^2 . Significant interactions between acceleration x frequency, and frequency x direction were also found. The largest average grip force increase was from 25.3 N without vibration to 35.8 N (42%) for 40 Hz and 49 m/s^2 vibration. The magnitude of this increase was of the same order as for a two-fold increase in load weight, where average grip force increased from 22.5 N to 35.0 N (56%). A second experiment studied hand flexor and extensor muscle responses using electromyography for five subjects holding a handle vibrating at 8 m/s^2 using ISO weighted acceleration, with frequencies of 20 Hz, 40 Hz and 160 Hz, and grip forces of 5%, 10% and 15% of maximum voluntary contraction. Muscle responses were greatest at frequencies where grip force was affected, indicating that the tonic vibration reflex was the likely cause of increased grip exertions.

Radwin, R.; VanBergeijk, E.; Armstrong, T. Muscle response to pneumatic hand tool

WELDING WORK

torque reaction forces. *Ergonomics*. 1989; 32(6): 655-74.

Surface electromyography was used for studying the effects of torque reaction force acting against the hand, on forearm muscle activity and grip force for five subjects operating right angle, air shut-off nutrunners. Four tools having increasing spindle torque were operated using short and long torque reaction times. Nutrunner spindle torque ranged between 30 Nm and 100 Nm. Short torque reaction time was considered 0.5 s while long torque reaction time was 2 s. Peak horizontal force was the greatest component of the reaction force acting against the hand and accounted for more than 97% of the peak resultant hand force. Peak hand force increased from 89 N for the smallest tool to 202 N for the largest tool. Forearm muscle rms EMG, scaled for grip force, indicated average flexor activity during the Torque- reaction phase was more than four times greater than the Pre- start and Post Shut-off phases, and two times greater than the Run-down phase. Flexor EMG activity during the Torque-reaction phase increased for increasing tool peak spindle torque. Average flexor rms EMG activity, scaled for grip force, during the Torque-reaction phase increased from 372 N for the 30 Nm nutrunner to 449 N for the 100 Nm nutrunner. Flexor rms EMG activity averaged during the Torque-reaction phase and scaled for grip force was 390 N for long torque reaction times and increased to 440 N for short torque reaction times. Flexor rms EMG integrated over the torque reaction phase was 839 Ns for long torque reaction times and decreased to 312 Ns for short torque reaction times. The average latency between tool spindle torque onset and peak initial flexor rms EMG for long torque reaction times was 294 ms which decreased to 161 ms for short torque reaction times. The average latency between peak tool spindle torque, just prior to tool shut-off, and peak final rms EMG for long torque reaction times was 97 ms for flexors and 188 ms for extensors, which decreased for short torque reaction times to 47 ms for flexors and 116 ms for extensors. The results suggest that right angle nutrunner torque reaction forces can affect extrinsic hand muscles in the forearm, and hence grip exertions, by way of a reflex response. These effects may be controlled by designing hand tools hand tools that minimize torque reaction forces transmitted to the hand using mechanical advantages provided from increased handle lengths, torque reaction bars or torque absorbing suspension systems, or minimizing muscle responses to rapid torque build-up by reducing tool spindle rotation speed.

WELDING WORK

Hagberg, M. Shoulder pain-pathogenesis. N. Hadler (Ed.). *Clinical Concepts in Regional Musculoskeletal Illness*. Orlando, Florida: Grune & Stratton; 1987: 191-200.

An examination of the pathogenesis of shoulder pain that focuses on degenerative joint disorder, tendinitis, myofascial disorder, and neurovascular disorder in the shoulder.

Hagberg, M.; Michaelson, G.; Ortelius, A. Serum creatine kinase as an indicator of local muscular strain in experimental and occupational work. *International Archives of Occupational & Environmental Health*. 1982; 50(4): 377-86.

Serum creatine kinase (SCK) was measured in ten subjects in the laboratory before and after the performance of bicycle ergometry and a lifting task. SCK was significantly increased 24 h and 48 h after the lifting work but not after the bicycle ergometry, although the work performed on the latter was four-times as

WELDING WORK

great as on the former. The lifting work resulted in muscle pain and tenderness and, for six subjects, in clinical signs of shoulder tendinitis. In a field study, an increase in SCK was noted among assemblers/welders and cash-register operators, but not among controllers and forklift-truck drivers. A health interview revealed that musculo-skeletal complaints were most often located in the upper extremity in the cases of the assemblers/welders and the cash-register operators. It is proposed that the SCK increase during work is a result of a high local muscular load due to fatigue and energy depletion of muscle cells producing a greater efflux of muscle enzymes. The evaluation of SCK changes during work may be an important tool in occupational health for early detection of work tasks producing local muscular strain.

Herberts, P.; Kadefors, R.; Broman, H. Arm positioning in manual tasks. An electromyographic study of localized muscle fatigue. *Ergonomics*. 1980; 23(7): 655-65.

Myoelectric activity in four different shoulder muscles was collected and interpreted as indirect indicators of the load in eight different arm positions. The power spectrum changes associated with localized muscle fatigue were measured using a new dedicated instrument. Localized muscle fatigue was present in all muscles, in overhead and shoulder level work, and in some cases in waist level work as well. For instance, in overhead work, the supraspinatus load was significantly affected by elbow positioning. The infraspinatus muscle held the highest fatigue effects of all muscles investigated. The results indicate the possibility of finding positions entailing reduction of the total muscular load in different working situations.

Herberts, P.; Kadefors, R.; Andersson, G.; Petersen, I. Shoulder pain in industry: an epidemiological study on welders. *Acta Orthopaedica Scandinavica*. 1981; 52(3): 299-306.

The occurrence of supraspinatus tendinitis in a group of welders at a shipyard was investigated, and compared with the occurrence of this condition in a group of office clerks. The study showed a prevalence ratio of 18 per cent in the welders, significantly higher than in the clerks. The average age (39 year) in the group with pain did not differ significantly from the average age in the entire group of welders. It is concluded that supraspinatus tendinitis is not exclusively an aging phenomenon, but that welding as an occupation plays an etiological role.

Herberts, P.; Kadefors, R.; Hogfors, C.; Sigholm, G. Shoulder pain and heavy manual labor. *Clinical Orthopaedics & Related Research*. 1984; 191: 166-78.

The problem of the increasingly common shoulder pain syndromes in industry was investigated by biomechanic and epidemiologic methods. Rotator cuff tendinitis constitutes a major problem in people with arduous occupations, i.e., shipyard welders (prevalence ratio, 18.3%), and steel plateworkers (16.2%). Static work seems to induce symptoms at an earlier age. The clinical diagnosis was supraspinatus tendinitis. The biomechanic studies confirmed the view that the shoulder muscles are heavily loaded when the arm is elevated. Excessive hand tool mass increases the strain markedly in some muscles, particularly the supraspinatus and the infraspinatus. The hypovascularity of the supraspinatus tendon is then likely to be accentuated by high intramuscular pressure that reduces the blood flow through the muscle. The strain on the supraspinatus muscle in overhead work is an important factor contributing to prolonged shoulder disability. An analysis of the distribution of loads imposed on the shoulder in practical working situations can be based on observations of working postures

WELDING WORK

and external forces.

Herberts, P.; Kadefors, R. A study of painful shoulder in welders. *Acta Orthopaedica Scandinavica*. 1976; 47(4): 381-7.
By means of clinical examination, soft tissue radiography and quantitative electromyography, the effect of heavy industrial work was evaluated on welders at a shipyard. The study revealed that the older workers with shoulder pain have a chronic tendinitis of the rotator cuff. The supraspinatus muscle was shown to be consistently fatigued during overhead welding. It is believed that this is an important factor in the aetiology of the shoulder pain commonly occurring in older welders.

Ritz, B.; Brunnhözl, K. Knee-joint lesions of pipe-fitters and welders employed by the public water and gas works. C. Hogstedt; C. Reuterwall (Eds.). *Progress in Occupational Epidemiology: Proceedings of the Sixth International Symposium on Epidemiology in Occupational Health*, Stockholm, Sweden, 16-19 August 1988. Amsterdam: Elsevier Science Publishers B.V.; 1988: 227-30.
A study examining to what extent pipefitting and welding are harmful for the knees of workers. These jobs include similar stresses for the knee-joints and the study focuses on the exposure time necessary to increase the risk for knee disorders. Pipefitters and welders working 11 to 15 years had a 3.5 and 3.3 (respectively) times higher risk for less specific knee-joint lesions and a 4.4 times higher risk for meniscus lesions compared to the unexposed group. The risks were lowest for those working less than 10 years and decreases again after 15 years, indicating a possible healthy worker effect. The results of the study show that the work of pipe-fitters and welders contains a high risk for knee-joint lesions.

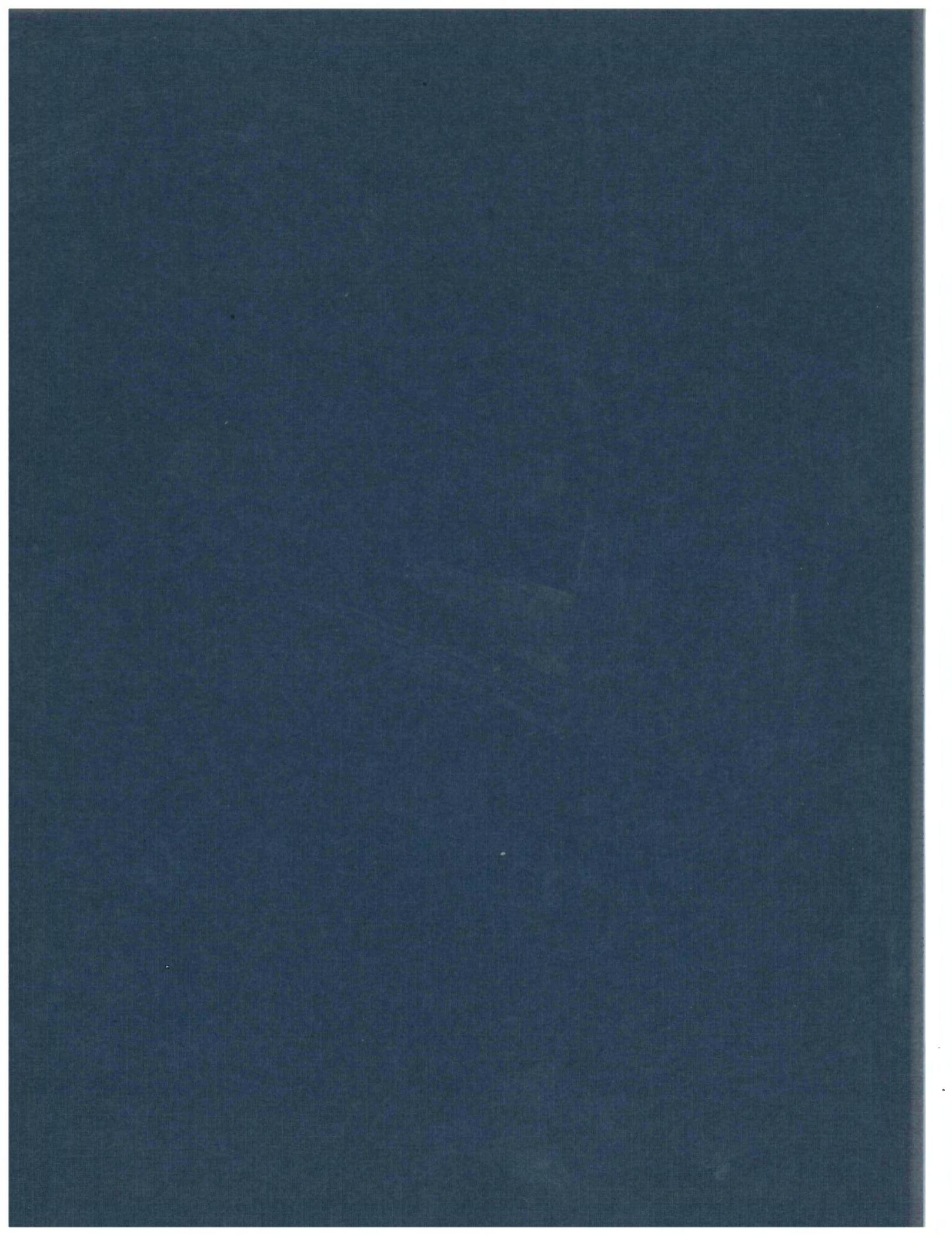
Torner, M.; Zetterberg, C.; Anden, U.; Hansson, T.; Lindell, V. Workload and musculoskeletal problems: a comparison between welders and office clerks (with reference also to fishermen). *Ergonomics*. 1991; 34(9): 1179-96.
Previous studies have shown that subjective as well as clinical shoulder signs and symptoms are more common among welders than among office clerks. In the present study we wished to further evaluate the influence of different jobs on musculoskeletal problems, as well as the relationship between objective signs and subjective symptoms. This study confirmed that symptoms and signs from the shoulder were more common among the welders, who also had more subjective symptoms and clinical signs from other parts of the musculoskeletal system. Range of motion in different joint systems was, however, similar in the two groups except in external rotation of the shoulder, where welders had a more limited range. The degree of co-existence of subjective symptoms and clinical signs differed between different parts of the musculoskeletal system and was low particularly in the low back, hips, and ankles. This indicates low validity of many common clinical methods for determining musculoskeletal dysfunction. General health was good in both vocational groups and isometric strength for the welders was intermediate between that of office clerks (who had lower strength) and that of fishermen (who had higher strength, as disclosed in a previous investigation). To a similar degree welders and fishermen also had objective signs from most parts of the musculoskeletal system, whereas subjective symptoms from some parts of the body and medical consultations due to these problems were more common among welders. Atrophied shoulder muscles were more common among welders than among fishermen, whereas crepitations in the shoulder tended to be more common among the fishermen. This indicates that heavy dynamic work and prolonged static work may both induce shoulder injuries, but of different types.

WELDING WORK

Wickstrom, G. Prevention of occupational back disorders - an intervention study. *Scandinavian Journal of Work, Environment & Health*. 1988; 14(Suppl 1): 116-17.

Note: NIOSH Abstract.

An intervention study carried out in Finland for prevention of occupational back disorders was described. The study attempted to address all possible risk factors except psychosocial factors. Three occupations in one company and two in another were studied in order to obtain large groups with homogeneous exposure to back loads. Only male workers aged 35 to 44 were studied. In a shipyard, work planners, welders, and plumbers were studied; planners and platers were studied in a factory that produced ventilation equipment for paper machines. Initial baseline values were determined for the incidence of low back disorders and for low back loads at work. Questionnaires, interviews, and physical tests were used for determining incidence of disorders, and annual workdays lost were calculated for each of 2 years based on occupation, sex, and age. Physical and psychological low back loads were determined using video taping, electromyography, and questionnaires. Only some baseline results had been analyzed so far for planning of interventions. Company personnel were included in determinations of which risks to approach and how to act on them. Some practical measures had already been put into effect. Future plans for the study following completion of the intervention phase included a 3 year followup of company absenteeism registers, questionnaires measuring occurrence of symptoms, and measurement of back loads to detect any changes.



TAB 2

APPENDIX 4

Ergonomic Exposure-Response Associations

ERGONOMIC EXPOSURE-RESPONSE ASSOCIATIONS

BRICKLAYERS

Exposures/Risk Factors:

- Heavy physical workload
- Awkward working positions
- Restriction in the standing position
- Repetitive movement or strain
- Energetic workload
- Overexertion

Outcomes:

- Low back disorders
- Lumbar load (at the lumbosacral disc)
- Lumbar paravertebral muscles (trunk extensor endurance and fatigue)
- Wrist disorders
- Epicondylitis
- Left upper limb (wrist, elbow, and shoulder)
- Cumulative trauma disorders

CARPENTERS

Exposures/Risk Factors:

- Awkward work postures (twisted or bent)
- Tool handles with sharp or hard edges
- Job satisfaction

Outcomes:

- Localized muscle fatigue--shoulder-arm
- Trigger finger

CARPET/FLOOR LAYERS

Exposures/Risk Factors:

- Overuse injury
- Kneeling work
- Knee kickers and impact knee-force

Outcomes:

- Knee arthrosis
- Prepatellar bursitis
- Knee-joint inflammation
- Bursitis
- Repetitive knee trauma

CONCRETE REINFORCEMENT WORKERS

Exposures/Risk Factors:

- Postural load
- Forward bending

Outcomes:

- Low back pain
- Sciatic pain
- Degenerative back disease
- Knee degeneration
- Radiographic changes

CRANE OPERATORS

Exposures/Risk Factors:

- Whole-body vibration
- Unfavorable work postures
- Climatic conditions

Outcomes:

- Low back pain and disorders
- Neck-shoulder regions

ELECTRICIANS

Exposures/Risk Factors:

- Strained postures
- Repetitive or forceful movements
- Previous acute injury

Outcomes:

- Carpal tunnel syndrome
- Low back pain or discomfort

- Neck discomfort
- Cumulative trauma disorders

OPERATORS OF HEAVY EQUIPMENT

Exposures/Risk Factors

- Whole-body vibration
- Unfavorable work postures
- Climatic conditions

Outcomes:

- Low back pain
- Intervertebral disc disorders

WELDERS

Exposures/Risk Factors:

- Prolonged static work
- Overhead work
- Heavy dynamic work

Outcomes:

- Shoulder pain syndromes
- Rotator cuff tendinitis
- Supra spinatus tendinitis
- Localized muscle fatigue

TAB 2

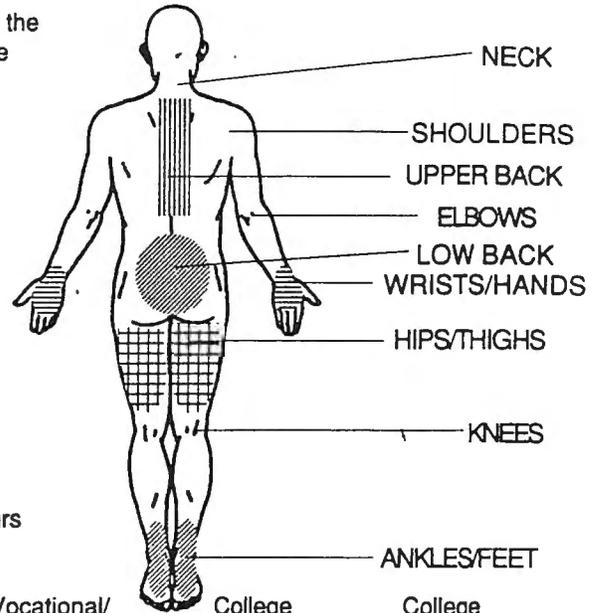
APPENDIX 5

Symptom/Job Factors Survey

SYMPTOM SURVEY

This survey is intended to obtain information about body aches and pains which you feel are job-related. It is meant to include conditions which you feel are aggravated by what you do at work. The information will be kept strictly confidential and will not be seen by your employer. Please respond honestly and thoughtfully.

In the picture you see the approximate position of the parts of the body referred to in the following questions. You have to decide in which part(s) you have or have had trouble (if any).



What year were you born? 19____

Sex: _____ male _____ female

How much do you weigh? _____ pounds

Are you _____ right or _____ left handed?

How tall are you? _____ feet _____ inches

How long have you been doing your present type of job? _____ years _____ months

On average, how many hours per week do you work? _____ hours

Level of Education _____ Elementary _____ High school _____ Vocational/ Technical _____ College Associate _____ College Graduate

To be answered by EVERYONE	To be answered ONLY by those who have had trouble	
Have you at any time during the <u>last 12 months</u> had trouble (ache, pain, discomfort, numbness, etc.) in: (check the appropriate answer)	Have you at any time during the last 12 months been <u>prevented from doing your day's work</u> (at home or outside the home) because of the trouble?	Have you had trouble during the <u>last 7 days</u> ?
NECK _____ No _____ Yes	_____ No _____ Yes	_____ No _____ Yes
UPPER BACK _____ No _____ Yes	_____ No _____ Yes	_____ No _____ Yes
LOW BACK _____ No _____ Yes	_____ No _____ Yes	_____ No _____ Yes
SHOULDERS Right: _____ No _____ Yes Left: _____ No _____ Yes	_____ No _____ Yes _____ No _____ Yes	_____ No _____ Yes _____ No _____ Yes
ELBOWS Right: _____ No _____ Yes Left: _____ No _____ Yes	_____ No _____ Yes _____ No _____ Yes	_____ No _____ Yes _____ No _____ Yes
WRISTS/HANDS Right: _____ No _____ Yes Left: _____ No _____ Yes	_____ No _____ Yes _____ No _____ Yes	_____ No _____ Yes _____ No _____ Yes
HIPS/THIGHS Right: _____ No _____ Yes Left: _____ No _____ Yes	_____ No _____ Yes _____ No _____ Yes	_____ No _____ Yes _____ No _____ Yes
KNEES Right: _____ No _____ Yes Left: _____ No _____ Yes	_____ No _____ Yes _____ No _____ Yes	_____ No _____ Yes _____ No _____ Yes
ANKLES/FEET Right: _____ No _____ Yes Left: _____ No _____ Yes	_____ No _____ Yes _____ No _____ Yes	_____ No _____ Yes _____ No _____ Yes

These questions are about things at work that could contribute to workplace pain or injury. For each item, put a mark in the column of the ONE statement that BEST describes your situation.

	Is NOT part of my job.	Is part of my job			
		but is NOT a problem for me.	and is a MINOR problem for me.	and is a MODERATE problem for me.	and is a MAJOR problem for me.
1. Performing the same task over and over.					
2. Working very hard for short periods (lifting, grasping, pulling, etc.)					
3. Having to manipulate or grasp small objects.					
4. Not enough rest breaks during the work day.					
5. Not enough stretching before or during work.					
6. Having to work in the same position for long periods (standing, bent over, etc.).					
7. Bending or twisting in an awkward or uncomfortable way (hand, elbow, back).					
8. Having to work so fast your muscles start to cramp or get sore.					
9. Reaching for something that is over your head or away from your body.					
10. Uncomfortable conditions (heat, cold, vibration).					
11. Workstation not adjusted to fit you (too high, too low, too small).					
12. Workstation not organized for easy use of materials and tools.					
13. Work scheduling problems (overtime, irregular shifts, too long of a work day).					
14. Tools/machines that are uncomfortable to use (too heavy, poor design).					
15. Not enough training on how to do the job.					

TAB 2

APPENDIX 6

Outline of Ergonomics Pilot Focus Groups in Iowa

Overview of Ergonomics

Overview of Industrial Ergonomics

A. Workspace

- Horizontal reach
- Vertical reach
- Work surface height
- Leg room
- Twisting
- Upper body posture

B. Work Posture

- Leaning
- Crouching
- Head and neck angle
- Shoulder and arm angle
- Hand and wrist angle
- Static holding

C. Seating

- Seat length, width, height, and angle
- Backrest, armrest, footrests
- Base of support, rotation, adjustability
- Leg space, thigh clearance

D. Displays

- Dial/indicator design
- Display organization
- Decision aids
- Symbols
- Lettering
- Viewing distance

E. Controls

- Reach
- Spacing
- Identification
- Control-display Layout
- Operational expectations
- Control-display relationships

Overview of Ergonomics

F. Manual Materials Handling

- Size, weight, and handgrip
- Starting and ending points of lifting
- Twisting and upper body movements
- Frequency and duration
- Footing and confined space

G. Manipulation

- Wrist posture
- Force exertions
- Grip dimensions
- Repetition rate
- Static holding

H. Hand Tools

- Grip size, span, shape
- Wrist angle
- Weight and balance
- Pressure and vibration

I. Heat/Lighting/Noise

- Temperature, humidity
- Age, work-rest schedules, clothing
- Illumination, glare, contrast, lines of sight
- Continuous and impact noise
- Speech interference

J. Training

- Trainee selection
- Task analysis
- Training content and methods

Bibliography

Putz-Anderson, V: Cumulative Trauma Disorders: A manual for musculoskeletal diseases of the upper limb. New York, Taylor & Francis, 1988.

Rodgers, SH(ed): Ergonomic Design for People at Work, Vol 1 & 2. New York, Van Nostrand Reinhold Company, 1986.

Webb ROG: Industrial Ergonomics. The School of Human Biology, The Industrial Accident Prevention Association, Ontario, 1982.



TAB 3

Biostatistics Center, George Washington University
Progress Report for Year Ending September 30, 1993

Surveillance for Work-Related Musculoskeletal Disorders
Among Construction Workers

SURVEILLANCE FOR WORK-RELATED MUSCULOSKELETAL DISORDERS
AMONG CONSTRUCTION WORKERS

Progress Report for Year Ending September 30, 1993

Biostatistics Center, George Washington University

The following is a report of the progress made through the end of the grant year on each of the elements of this project.

Medical Care Claims

Background Work has been underway for the past three years on the development of a data system for analysis of medical care claims from several of the local health and welfare funds of the Laborers' International Union of North America. This effort was begun by the Laborers' Health and Safety Fund of North America and is currently being expanded to other unions in the construction trades through the Center to Protect Workers' Rights. This has made it possible to study rates of hospitalization for specific disorders and rates of visits to doctors' offices for conditions that are not necessarily thought to be work-related.

The health and welfare funds cover only the health care that is not known to be work-related. The work-related claims are covered by Workers' Compensation. Thus, at the present time, no set of data exists that portrays the total medical care experience of these worker populations. We are now working out a relationship with the Department of Labor and Industries in the State of Washington, who handle the Workers' Compensation claims for that state, to link our data with theirs. This will permit us to obtain a total health care picture for the workers and to study the relationships between the work-related conditions and other medical conditions in the same individuals.

Negotiations are also underway with some of the local health and welfare funds of some of the other unions in the construction trades to incorporate their claims data into the system and to also link their data with Workers' Compensation claims. This will permit us to carry out similar analyses for those trades and also to make comparisons of medical care among the trades.

To establish a surveillance component for musculoskeletal disorders among construction workers, based on medical care claims data, we plan to extend our current system and to focus it specifically on those disorders and also to analyze data that will be available from other sources.

Progress to date The medical care claims data sets for the Laborers' Union local health and welfare funds that have been participating since 1989 have been updated and attempts have been made to obtain claims data from locals of other construction trades. The details are briefly as follows:

- ⌘ Both the eligibility files for health insurance and the medical care claims files for Northwest Laborers, Massachusetts Laborers, and the West Texas-New Mexico Multicraft have been updated through 1991. Therefore, data for the three-year period, 1989-1991, are now available for analysis. In addition, data for the Indiana Laborers have been obtained for 1991, thus making it possible to compare 1991 data with those for 1989.
- ⌘ We have been negotiating with four locals from other trade unions in construction covering the state of Washington to participate in the medical care claims data system. Although no agreements have yet been reached, the Bricklayers and the Painters are expected to join the system.
- ⌘ We have obtained a listing of clients of the Union Labor Life Insurance Company (ULLICO) and their subsidiary, Zenith Administrators, and will be able to obtain claims data on a selected set of them as soon as the work station has been set up at the Center to Protect Workers' Rights for access to the ULLICO main frame computer. ULLICO has made available a sample data base for its claims system with interactive software for analysis, but the actual claims data have not yet been entered into the system.

Workers' Compensation data

We have been investigating the possibility of linking the file of those eligible for health insurance among members of the Northwest Laborers and the Massachusetts Laborers to obtain the total medical care picture among these workers.

Progress to date

- ⌘ For the Northwest Laborers, we have worked out a protocol for this linkage study with the Washington State Department of Labor and Industries and have submitted a fairly detailed "grant application" for review by the Institutional Review Board at the George Washington University and by the Institution Review Board of the Washington State Department of Social and Health Services. This has been necessary because the project involves obtaining names and other identifiers for the workers in order to match data sets. We have now received approval from both Institutional Review Boards. We have received a signed confidentiality agreement from the state of Washington to cover the handling of the data. We then sent copies of these approval documents and signed confidentiality agreements to the Board of

Trustees of the Northwest Laborers-Employers Health and Security Trust of the Northwest Laborers with a request for them release the names of the workers to us. A confidentiality agreement was signed by both the management and labor trustees of the Health and Security Trust and we have obtained the names for the matching process. the matching will proceed shortly.

- ⋮ In the process of investigating the possibility of carrying out a similar linkage study in Massachusetts, we discovered that there are many insurance carriers for workers' compensation in the state of Massachusetts as compared with a single carrier in Washington (the state). This would make it virtually impossible to carry out the type of study in Massachusetts that we plan to conduct in the state of Washington. Therefore, we will confine our activities on workers compensation to obtaining such information only on workers in the various trades involved in the Boston Artery project. There will be only a single carrier for workers' compensation for that project. We will coordinate this activity with the Occupational Health Clinic at Harvard University and the Massachusetts General Hospital.

Develop measures for musculoskeletal disorders

Our analyses of medical care claims data up to this point has considered only certain aspects of medical care and has not concentrated on any particular condition or group of conditions. For example, we have analyzed hospital admissions and doctors' office visits, but for each 3-digit category of the ICD. By concentrating on musculoskeletal disorders, we will attempt to define episodes of care that take into account all of the medical care an individual with a musculoskeletal diagnosis receives and to determine what other diagnoses might be related.

Progress to date We have met with the Principal Investigator and the epidemiologist from the George Washington University Occupational Medicine Clinic to work out a preliminary list of 3-digit ICD categories likely to contain work-related musculoskeletal disorders. A copy of this list is attached. We have shared this with the other members of the consortium at the University of Iowa and the University of Massachusetts at Lowell and this will serve as a basis for further discussion and refinement with the Surveillance Working Group.

Analyses of data from other existing sources

There are at least two consistent sources of national morbidity data on medical conditions classified according occupation - the Annual Survey of Occupational Injuries and Illnesses of the Bureau of Labor Statistics and the National Health Interview Survey (NHIS) of the National Center for Health Statistics. We will obtain data tapes from each of those sources and develop an analysis of musculoskeletal disorders for each of the trades in the construction industry that can be repeated from year to year. This will be a surveillance device that will be lacking in detail, but it may provide clues that will point toward hypotheses that can be tested using our medical care claims data. The Supplementary Data System (SDS) of the BLS, containing workers' compensation data, was discontinued after 1990 because of problems of lack of uniformity and data quality among states. However, data tapes are available from earlier years and the detail available may have implications for aiding in the interpretation of the NHIS data and the data from the BLS Annual Survey.

Progress to date We have obtained copies of the data tapes for the NHIS With the occupational supplement for 1988, the BLS Annual Survey for 1976-1989, and the SDS for 1987 and will be producing tabulations as soon as the computer work station at CPWR has been set up.

Comment

It should be pointed out that the use of medical care claims data to obtain information about work-related musculoskeletal disorders will depend heavily on the workers compensation data. Once the matching described has been completed for the Northwest Laborers, we will then be able to assess the extent of WMDs among this group and the extent to which such disorders appear in the claims covered by the health and welfare fund. This may be of help in interpreting the data from other health and welfare funds, for which paid claims are not supposed to cover work-related conditions.

Surveillance Working Group

Although the WMD Surveillance Working Group has not met since the meeting of the consortium in Lowell in march, 1993, there has been some contact among the members by telephone and mail in the interim. The following is a brief statement of the status of the surveillance activities of each of the consortium members as of September, 1993.

University of Iowa

The Rural Injury Surveillance System (RISS) has been implemented in eight of the proposed ten hospital emergency rooms. The other two ERs are now on line. Now that the hospitals have had four months of experience working with the system, the data that have been coming in monthly have revealed a number of problems. A meeting with the participants has been scheduled for the last week of September to review the problems and share experiences with the system. The major concerns thus far have been the following:

1. The SIC and SOC coding has been missing in 30%-50% of the cases, thus making the classification of injuries by industry and occupation very questionable.
2. Although the N-coding from the International Classification of Diseases is good, E-coding (external causes of injury) is being done by only half of the ERs.

These problems will be dealt with at the September meeting with the hospital representatives.

George Washington Univ. Occupational and Environmental Medicine

The GWU has been receiving case reports on conditions related to occupational or environmental exposures from the member clinics of the Association of Occupational and Environmental Clinics (AOEC). Reports on construction cases seen between January 1991 and June 1993 have come from 16 AOEC clinics. During that period there were 730 cases seen among construction workers. Of these, 124 were related to physical exposures, which include the cases of WMD. It should be pointed out that this is not a series of cases that is representative of the experience of construction workers in the U.S. Construction workers are seen in these clinics because they are referred by unions or attorneys or because of screening programs offered by the clinics.

Dr. Welch has organized a meeting of the AOEC clinics at the APHA meeting in San Francisco on October 25 to discuss issues related to the WMD project. The items to be discussed include the following:

1. Description of the goals of the WMD project and of the Center to Protect Workers' Rights.
2. Presentation of data collected on WMD and reported to the AOEC data base.
3. Development of materials that the clinics could send to construction worker union locals to increase their referrals to the clinics.

4. Presentation of a study plan and discussion of the details of a longitudinal study of WMD cases.
5. Discussion of the formation of an AOEC working group on work-related musculoskeletal disorders and other ideas for collaboration among the clinics.

George Washington Univ. Biostatistics Center

The Biostatistics Center has been receiving medical care claims data from four of the Laborers' Union International (LIUNA) locals covering the period 1989-1991. Data for services provided in 1992 will be received about November, 1993. These are claims for medical care for presumed non-work-related conditions. A major aspect of this project is a study to be conducted in the state of Washington in which the medical care claims for the Northwest Laborers from their union health insurance will be linked with Workers' Compensation claims from the Department of Labor and Industries (L&I) for 1990 and 1991. To carry out this linkage requires basic identifying information, including names, from the Northwest Laborers and the maintenance of strict confidentiality of the data. Obtaining the necessary clearances requiring review of the study protocol by the George Washington University Institutional Review Board and by the IRB in the Washington State Department of Social and Health Services. These approvals led to confidentiality agreements between the Biostatistics Center and the Department of L&I and between the Biostatistics Center and the Northwest Laborers. This process has taken about 9 months, but the information with identifiers ready for the matching procedures finally arrived at the Department of L&I On September 27, 1993.

This study will make it possible to analyze the total medical care experience of these construction laborers and to study the relationship between the clearly work-related and other medical conditions among this group of workers. Some preliminary tabulations of the non-work-related medical care among these workers for 1990 revealed that about 15% of them had at least one diagnosis in ICD categories likely to contain work-related musculoskeletal disorders. These accounted for about 5% of the total expenditures by their health insurance plan. Hopefully by the end of November we will be able to relate this experience to Workers' Compensation claims. During the year, the GWU Occupational and Environmental Medicine and Biostatistics Center participants met and developed a list of three-digit ICD categories likely to contain work-related musculoskeletal disorders. This was circulated among the consortium and was intended as a list to be experimented with as data from the various projects became available. A copy of the list is attached. In the process of gaining experience with this list, we hope to be able to obtain estimates from different data sets of the proportion of actual WMD diagnoses in each of these categories.

University of Massachusetts-Lowell

The surveillance for work-related musculoskeletal disorders on this part of the project will involve identification of those disorders among workers on the Boston Artery project. As of this time, permission has not been granted for the UMass-Lowell and Massachusetts General Hospital staff to go onto the site. However, this permission is expected within the next few weeks. Meanwhile a draft of a questionnaire has been developed to be administered to workers on the site to ascertain occupational history, history of work-related injury, and the occurrence on this job of work-related injuries, including specifically work-related strains and sprains. In addition, focus groups are being set up with local unions to get at some of these issues.

Center to Protect Workers' Rights - Data Center

The Data Center has accumulated a number of large national data sets on morbidity and mortality to be able to tabulate data on injuries and illness among construction workers. Thus far, only one-dimensional frequency distributions have been produced from some of them to obtain some idea of what kinds of tabulations might be useful. For most of these data sets, it is difficult to identify precisely the work-related musculoskeletal disorders. Using the 1987 data for California from the Supplementary Data System of the Bureau of Labor Statistics, for example, of the 51,193 injuries among construction workers, 17,796, or 35%, were sprains and strains. However, it was not possible to determine how many of those were due to acute exposures and how many to chronic repetitive exposure. As soon as we receive the data tape for the Occupational Supplement to the 1988 National Health Interview Survey, we will be able to obtain some national estimates of the prevalence of some WMDs among construction workers.

The Data Center will have access to medical care claims data for clients of the Union Labor Life Insurance Company. They have contracted to have a "data warehouse" developed to make possible the production of reports interactively from their claims data. A prototype of this system is now available, but the client data is not yet on-line. As soon as it is, we will select two or more clients in the construction trades to analyze their data for WMD claims.

**ICD Codes for Musculoskeletal Disorders that Result
from Chronic Exposures**

The range of ICD categories that were considered as possibly containing musculoskeletal disorders that could have resulted from chronic exposures were the following: 350-359; 710-739; and 840-848. The following is a listing of the three-digit codes within this range with a notation for each as to whether to exclude the category as not being relevant, whether to include it, and if so, whether most of the specific diagnoses within the category, or only some of them, would likely result from chronic exposures.

ICD Code	Diagnostic Category	Status (M)= Most (S)= Some
350	Trigeminal nerve disorders	Exclude
351	Facial nerve disorders	Exclude
352	Disorders of other cranial nerves	Exclude
353.0	Brachial plexus lesions	Include
Other 353	Other nerve root and plexus disorders	Exclude
354	Mononeuritis of upper limb & mononeuritis multiplex	Include (M)
355	Mononeuritis of lower limb	Include (S)
356	Hereditary and idiopathic peripheral neuropathy	Exclude
357	Inflammatory and toxic neuropathy	Exclude
358	Myoneural disorders	Exclude
359	Muscular dystrophies and other myopathies	Exclude
710	Diffuse diseases of connective tissue	Exclude
711	Arthropathy assoc. with infections	Exclude
712	Crystal arthropathies	Exclude
713	Arthropathy assoc. with other disorders classified elsewhere	Exclude
714	Rheumatoid arthritis and other inflammatory polyarthropathies	Exclude
715	Osteoarthritis and allied disorders	Include (M)
716	Other and unspecified arthropathies	Include (S)

ICD Code	Diagnostic Category	Status (M)= Most (S)= Some
717	Internal derangement of knee	Include (M)
718	Other derangement of joint	Include (S)
719	Other and unspec. disorders of joint	Include (S)
720	Anklyosing spondylitis and other inflam. spondylopathies	Exclude
721	Spondylosis and allied disorders	Include (M)
722	Intervertebral disc disorders	Include (M)
723	Other disorders of cervical region	Include (S)
724	Other and unspec. disorders of back	Include (M)
725	Polymyalgia rheumatica	Exclude
726	Periphal enthesopathies	Include (M)
727	Other disorders of synovium, tendon, and bursa	Include (S)
728.6	Contracture of palmar fascia	Include
Other 728	Other disorders of muscle, ligament, and fascia	Exclude
729	Other disorders of soft tissue	Exclude
730	Osteomyelitis, periostitusand other infections involving bone	Exclude
731	Osteitis deformans and osteopathies assoc. with oth. disorders classified elsewhere	Exclude
732	Osteochondropathies	Exclude
733	Other disorders of bone and cartilage	Exclude
734	Flat foot	Exclude
735	Acquired deformities of toe	Exclude
736	Other acquired deformities of limbs	Exclude
737	Curvature of spine	Exclude
738	Other acquired deformity	Exclude
739	Nonallopathic lesions, NEC	Exclude

ICD Code	Diagnostic Category	Status (M)= Most (S)= Some
840	Sprains and strains of shoulder and upper arm	Include (M)
841	Sprains and strains of elbow and forearm	Include (M)
842	Sprains and strains of wrist and hand	Include (M)
843	Sprains and strains of hip abd thigh	Include (M)
844	Sprains and strains of knee and leg	Include (M)
845	Sprains and strains of ankle and foot	Include (M)
846	Sprains and strains of sacroiliac region	Include (M)
847	Sprains and strains of other and unspec. parts of back	Include (M)
848	Other and ill-defined sprains and strains	Exclude

TAB 4

George Washington University (GWU) Subcontract, Year
1 Summary Report 9/30/92 - 9/29/93:

Reducing Work-Related Musculoskeletal Disorders
(WMD) Among Carpenters and Related Construction
Workers

REDUCING WORK-RELATED MUSCULOSKELETAL DISORDERS (WMD) AMONG CARPENTERS AND RELATED CONSTRUCTION WORKERS

GEORGE WASHINGTON UNIVERSITY (GWU) SUBCONTRACT

YEAR ONE SUMMARY REPORT, 9/30/92 - 9/29/93

The GWU component addresses two areas under the overall project: (a) health surveillance through the AOEC Database; and (b) longitudinal studies. The Year 1 goals related primarily to health surveillance; planning and carrying out the longitudinal study is the major focus of Year 2.

The Association of Occupational and Environmental Clinics (AOEC) has developed a database containing standardized data on cases of occupational disease or injury seen in the member clinics. Cases included in the Database are those which the clinician has diagnosed as being related to an occupational or an environmental exposure. The Database contains information primarily on illnesses, repetitive strain injuries, and acute musculoskeletal injuries such as back strain; other acute injuries are rarely treated by member clinics. For each patient, the Database includes demographic data, information on occupational and industry, and data on up to three diagnoses and three exposures related to those diagnoses. The AOEC Database is the source for this project of surveillance data on construction workers with work-related musculoskeletal disorders.

The first priority of Year One was to increase the number of cases of construction work-related musculoskeletal disorders in the AOEC Database. We made some progress in this area by publicizing this project within the AOEC, and by encouraging clinics to report their cases. Most clinics, however, see few cases of work-related musculoskeletal disease among construction workers, so this is an area where additional effort is necessary in Year Two. We will be working with CPWR to prepare outreach materials that could be used by the participating clinics to increase referrals for construction workers with WMD patients.

The table in the GWU Appendix presents data on 109 cases of work-related musculoskeletal disease seen among construction workers. This information came from the AOEC Database as of 10/93. Raynaud's syndrome (48 cases) and carpal tunnel syndrome (38 cases) were the most common diagnoses, with other diagnoses such as low back pain and epicondylitis reported much less frequently. The table also identifies the clinics reporting cases and the distribution of diagnoses by shipyard and non-shipyard diagnoses. The table shows that most cases of Raynaud's syndrome and carpal tunnel syndrome were from shipyard workers treated at the Yale clinic.

Another Year One priority was to improve the quality of the data reported to the AOEC on WMD among construction workers. Dr. Welch developed a standardized protocol for AOEC clinicians to use in the assessment of patients complaining of musculoskeletal symptoms. After circulating the protocol and discussing it with AOEC clinicians, the consensus was that the protocol was too cumbersome. The decision was that for case identification and followup, this project would rely on each clinician's expert opinion regarding WMD diagnoses.

We had also proposed that clinics use standardized exposure codes to describe ergonomic hazards which contribute to WMDs. Exposure coding criteria have been developed by Dr. Hunting as part of the other CPWR/NIOSH Cooperative Agreement. These codes describe physical exposures which related to acute and chronic musculoskeletal disorders, including cold, vibration, postural stress, and repetitive movements. In addition to the codes from the Physical Factors category and Ergonomic Factors category which are shown in the GWU Appendix, the user is prompted to enter more detail (if available) when a hazard from the Ergonomic Factors category is chosen.

During Year One, twenty five AOEC Clinics have agreed to collect the additional information needed to report cases for this project. Fourteen of these contribute cases to the AOEC Database, and the remaining eleven have agreed to contribute cases for this project alone. We expect that this latter group of clinics will begin to contribute all of their cases in the near future when the updated version of the AOEC Database software is made available.

Remaining Year One activities focused on planning for the longitudinal study of cases of construction worker WMD identified by the AOEC participants. Clinics will conduct a chart review of each case, completing a standardized form detailing relevant exposures, symptom severity, and recommended treatments. Then, a followup telephone interviews with each case will focus on current symptom severity, treatments obtained, and employment/outcome considerations. Drs. Welch and Hunting planned to discuss study methods and draft data collection forms at a meeting of participating clinics to be held in San Francisco during the APHA meeting in late October. The draft data collection forms which were discussed in San Francisco are included in the GWU Appendix.*

* Postscript: The meeting in San Francisco was quite successful -- representatives from almost every clinic attended. Based upon the results of that meeting, data collection forms have since been revised, and the study protocol further developed. Further details will be forthcoming in Year Two progress reports.

GWU APPENDIX

- (1) Work-Related Musculoskeletal Diseases Among Construction Workers, AOEC Database, 10/93 (N = 109 cases)
- (2) New AOEC Database Exposure Codes, Physical Factors and Ergonomic Factors
- (3) AOEC Clinic Form -- Ergonomic Exposures and Symptom Severity (abstract form for chart review, draft 10/13/93, has since been revised)
- (4) Musculoskeletal Symptom Follow-up Survey for Construction Workers (questionnaire for telephone follow-up, draft 10/14/93, has since been revised)

TAB 4

APPENDIX 1

Work-Related Musculoskeletal Diseases Among
Construction Workers: AOEC DATA BASES, 10/93
(N=109 Cases)

WORK-RELATED MUSCULOSKELETAL DISEASES AMONG CONSTRUCTION WORKERS, AOEC DATABASES, 10/93 (N = 109 cases)

<u>ICD-9</u>	<u>DIAGNOSIS BY CLINIC</u>	<u>FREQ</u>	<u>NON-SHIPYARD OCCUPATIONS</u>	<u>SHIPYARD OCCUPATIONS</u>
443.0	RAYNAUD'S SYNDROME/VIBRATION WHITE FINGER Yale University* (46)	48	Boilermaker	Grinder (22) Welder (5) Shipfitter (4) Pipefitters (3) Painter (3) Carpenter (2) Driller (2) Electrician Electronic mechanic Inspector Machinist
	Cook County Hospital (1) Rhode Island (1)		Carpenter	Grinder
354.0	CARPAL TUNNEL SYNDROME Yale University (30)	38	Pipefitter/Steamfitter (3) Insulator	Grinder (5) Welder (5) Machinist (3) Painter (3) Pipefitter (3) Shipfitter (2) Carpenter Electrician Mechanic Planner Rigger
	Harborview Hospital (4) Cook County Hospital (1) George Washington University ^b (2) Wayne State University (1)		Carpenter (3) Unknown Laborer Helper Rodman Demolition worker	

<u>ICD-9</u>	<u>DIAGNOSIS BY CLINIC</u>	<u>FREQ</u>	<u>NON-SHIPYARD OCCUPATIONS</u>	<u>SHIPYARD OCCUPATIONS</u>
724.2	CHRONIC LOW BACK PAIN George Washington University (7)	7	Rodman Laborer Painter Sheetmetal mechanic	(4)
726	ELBOW/SHOULDER TENDINITIS/BURSITIS Harborview Hospital ^c (5)	5	Carpenter	(2) Insulator Laborer Unknown
727.04	DE QUERVAIN'S DISEASE Yale University (4)	4		Carpenter (2) Painter (2)
723.4	BRACHIAL NEURITIS OR RADICULITIS, NOS Yale University (2) George Washington University (1)	3	Electrician	Painter Shipfitter
726.32	EPICONDYLITIS, NOS George Washington University ^b (1) Yale University (1)	2	Rodman Laborer	
726.90	TENDINITIS, NOS George Washington University (1) Cambridge Hospital (1)	2	Painter Carpenter	
354.2	ULNAR NERVE IRRITATION George Washington University ^d (1)	1	Rodman	

<u>ICD-9</u>	<u>DIAGNOSIS BY CLINIC</u>	<u>FREQ</u>	<u>NON-SHIPYARD OCCUPATIONS</u>	<u>SHIPYARD OCCUPATIONS</u>
357.2	PERIPHERAL NEUROPATHY EXACERBATION Yale University ^a (1)	1		Welder
715.9	OSTEOARTHRISIS Yale University ^a (1)	1		Machinist
716.1	POST-TRAUMATIC ARTHRITIS Yale University (1)	1		Welder
722	INTERVERTEBRAL DISC DISORDER Harborview Hospital (1)	1	Plumber/pipefitter/welder	
726.3	ENTHESOPATHY OF THE ELBOW REGION Yale University (1)	1		Grinder
727	HAND/WRIST TENDINITIS Harborview Hospital (1)	1	Laborer	
728.85	LOWER BACK MUSCLE SPASM George Washington University (1)	1	Rodman	
846.9	LOW BACK STRAIN Oklahoma University (1)	1	Carpenter	
848.8	UPPER EXTREMITY SPRAINS/STRAINS Harborview Hospital (1)	1		Shipscaler

^a This is the second diagnosis for 4 cases; Carpal Tunnel Syndrome is the first diagnosis

^b This is the second diagnosis for 1 case; Low Back Pain is the first diagnosis.

^c This is the second diagnosis for 1 case; Carpal Tunnel Syndrome is the first diagnosis.

^d This is the third diagnosis for this case; Low Back Pain is the first diagnosis and Epicondylitis is the second diagnosis.

^e This is the second diagnosis for this case; Carpal Tunnel Syndrome is the first diagnosis.

TAB 4

APPENDIX 2

AOEC Exposure Coding System (Excerpt)

This exposure coding system was developed by Katherine Hunting, PhD, MPH and Susan Donald, MS, CIH for the Association of Occupational and Environmental Clinics (AOEC), with support through NIOSH Cooperative Agreement U60/CCU306169. For further information, contact the AOEC office at (202) 347-4976.

AOEC EXPOSURE CODING SYSTEM (EXCERPT)

CATEGORIES, <u>Sub-categories</u>			
Existing AOEC Code	Primary Exposure Name (Synonyms)	Use Group*	New AOEC Exp Code
PHYSICAL FACTORS			350
F	PHYSICAL FACTORS, NOS		350.00
F04	NOISE		350.01
F20	COLD (LOW TEMPERATURE)		350.02
F02	HEAT (THERMAL ENERGY; HIGH TEMPERATURE; HOT LIQUID; STEAM)		350.03
F17	HEAT (THERMAL ENERGY; HIGH TEMPERATURE; HOT LIQUID; STEAM)		350.03
F30	HEAT (THERMAL ENERGY; HIGH TEMPERATURE; HOT LIQUID; STEAM)		350.03
	HUMIDITY, LOW (DRY AIR)		350.04
F25	HUMIDITY, HIGH (MOISTURE; WET WEATHER)		350.05
<u>Ionizing Radiation</u>			351
	RADIATION, IONIZING, NOS		351.00
	PLUTONIUM		351.01
	NUCLEAR REACTOR RELEASE		351.02
	RADON		351.03
	THERAPEUTIC RADIATION (XRAYS; RADIOISOTOPES)		351.04
	URANIUM		351.05
<u>Non-Ionizing Radiation</u>			352
	RADIATION, NONIONIZING, NOS		352.00
	RADIATION, ELECTROMAGNETIC (EMF; ELECTROMAGNETIC FIELDS; ELF; EXTREMELY LOW FREQUENCY ELECTROMAGNETIC RADIATION; VDT RADIATION; CRT RADIATION)		352.01
F21	LASERS		352.02
F08	RADIATION, MICROWAVE (RADIO FREQUENCY RADIATION)		352.03
F18	RADIATION, ULTRAVIOLET (UV RADIATION; UV LIGHT)		352.04
<u>Trauma-Related Exposures</u>			353
F06	TRAUMA, ACUTE, NOS		353.00
F28	ELECTRICAL SHOCK (ELECTRICITY)		353.01
F29	EXPLOSION		353.02
F22	FALL		353.03
F19	HYPOXIA (OXYGEN DEFICIENCY; SUFFOCATION)		353.04
F23	MOTOR VEHICLE ACCIDENT (CAR ACCIDENT; AUTO ACCIDENT; CAR CRASH)		353.05
<u>Vibration</u>			354
F03	VIBRATION, NOS		354.00
	VIBRATION, REGIONAL (HAND-ARM VIBRATION; LOCAL VIBRATION)		354.01
	VIBRATION, WHOLE BODY		354.02

	ERGONOMIC FACTORS	360
	ERGONOMIC FACTORS, NOS	360.00
F05	CONTACT PRESSURE (MECHANICAL PRESSURE; SKIN CONTACT)	360.01
F26	KEYBOARD USE (COMPUTER KEYBOARD; VDT KEYBOARD; VDT TYPING; ADDING MACHINE; CALCULATOR; KEY PUNCHING; TYPING; TYPEWRITER; WORD PROCESSING)	360.02
F15	REPETITIVE MOTION (REPETITIVE TRAUMA)	360.03
F14	REPETITIVE MOTION (REPETITIVE TRAUMA)	360.03
F10	STRESS (PSYCHOLOGICAL FACTORS; MENTAL FACTORS; JOB DEMAND; JOB CONTROL; ROTATING SHIFTS)	360.04
	VDT SCREEN/VISUAL	360.05
	<u>Force</u>	361
	FORCEFUL MOVEMENTS, NOS (HIGH FORCE; PULLING; PUSHING)	361.01
F24	LIFTING (CARRYING; REPETITIVE LIFTING; HEAVY LIFTING)	361.02
F27	GRIPPING, FORCEFUL (PINCHING; HANDWRITING)	361.03
	<u>Posture</u>	362
	POSTURE, NOS	362.00
	POSTURE, UPPER EXTREMITY (UPPER EXTREMITY AWKWARD POSITIONS; HAND-ARM POSTURE)	362.01
	POSTURE, BODY - STATIC (PROLONGED POSITION; STANDING; SITTING; KNEELING)	362.02
	POSTURE, BODY - DYNAMIC (BENDING; TWISTING; STOOPING)	362.03

* Use Group Codes: S = Solvent; P = Pesticide

TAB 4

APPENDIX 3

Work-Related Musculoskeletal Disorders Among
Construction Workers, AOEC Clinic Form -- Ergonomic
Exposures and Symptom Severity

WORK-RELATED MUSCULOSKELETAL DISORDERS AMONG CONSTRUCTION WORKERS

AOEC CLINIC FORM -- ERGONOMIC EXPOSURES AND SYMPTOM SEVERITY

This form should be used to describe ergonomic exposures and symptom severity for CONSTRUCTION WORKERS with MUSCULOSKELETAL DISORDERS.

Questions? Please contact Laura Welch, MD or Kathy Hunting, PhD at (202) 994-1734.

A. Identifier

Clinic ID _____

Patient ID _____

(If case not submitted to AOEC Database, please complete AOEC Database coding form.)

Submitted to AOEC Database Y N

B. Job Tasks

Describe the job tasks or exposures which, in your opinion, caused or contributed to the patient's musculoskeletal disorders. Be specific about ergonomic factors such as postural strain, forceful exertion, lifting or carrying, and vibration. Also note how long the patient had been working under each specified condition (up until their first visit with you). If there are any acute exposures or injuries which contributed to a sudden-onset condition, list them separately from chronic exposures.

Task or Exposure - Chronic

Duration of Exposure

1.		
2.		
3.		
4.		

Task, Exposure, or Injury - Acute

Duration of Exposure

1.		
2.		

Please complete other side. -----> -----> -----> -----> -----> ----->

C. Symptom Severity

1. How long have symptoms been:

noticeable? _____

moderate? _____

severe? _____

(If symptoms began in past 3 months, skip to Question 3.)

2. If the patient has been symptomatic for some time, what motivated the him/her to seek medical attention at this time? Please note motivating factors such as change in severity of condition, change in work demands, psychological factors, or workers' compensation.

3. To what extent have the symptoms affected the patient's work or leisure activities?

	Not at all	Minor or Moderate	Major or Substantial
a. Interference with leisure or household activities?	[]	[]	[]
b. Change in work assignments?	[]	[]	[]*
c. Decrease in productivity?	[]	[]	[]*
d. Change in the way patient does work tasks?	[]	[]	[]*

* Explain: _____

4. What did you recommend for treatment (at time of first 1-3 visits)? Circle all that apply.

- a. surgery
- b. physical therapy
- c. light duty assignment
- d. temporary total disability
- e. job modifications (explain below) *
- f. vocational rehabilitation/job retraining
- g. other (explain below) *

* Explain: _____

TAB 4

APPENDIX 4

Musculoskeletal Symptom Follow-Up Survey for
Construction Workers (Draft, 10/14/93)

Date of Last Clinic Visit ___/___/___

Clinic ID Code _____

Date of Interview ___/___/___

Patient ID Code _____

Interviewer Initials _____

MUSCULOSKELETAL SYMPTOM FOLLOW-UP SURVEY FOR CONSTRUCTION WORKERS (DRAFT, 10/14/93)

Interviewer: Circle affected body part and refer to this body part throughout this questionnaire.

- | | |
|-----------------|-------------------------|
| 1 NECK | 5 BACK |
| 2 SHOULDER | 6 KNEE |
| 3 ELBOW/FOREARM | 7 OTHER (SPECIFY) _____ |
| 4 HAND/WRIST | |

[Question for discussion: If more than one body part was affected, should we ask about all problems at once, or use a separate page for each affected location?]

PART A. SYMPTOM SEVERITY

1. "Since your last visit to our clinic on ___/___/___, have you continued to have a problem with your [body part] _____?"

0 no ---> IF NO, GO TO PART B.
1 yes

2. "Since your last visit with us, has your _____ problem gotten a lot better, a little better, a little worse, a little better, or stayed about the same?"

1 a lot better
2 a little better
3 stayed about the same
4 a little worse
5 a lot worse

If last visit was more than one year before interview ---> GO TO QUESTION 4

3. "In the PAST YEAR have you experienced any pain, aching, stiffness, burning, numbness, or tingling in your _____?"

0 no ---> IF NO, GO TO PART B.
1 yes

4. "How often have you had this _____ problem in the PAST YEAR?"

1 almost never (every 6 months)
2 rarely (every 2-3 months)
3 sometimes (once a month)
4 frequently (once a week)
5 almost always (daily)

PART A, continued. SYMPTOM SEVERITY

Clinic ID Code _____

Patient ID Code _____

5. "How long does this _____ problem usually last?"

- 1 less than 1 hour
- 2 1 hour to 1 day
- 3 more than 1 day to 1 week
- 4 more than 1 week to 2 weeks
- 5 more than 2 weeks to 4 weeks
- 6 more than 1 month to 3 months
- 7 more than 3 months

6. "On average over the **PAST YEAR**, would you call this discomfort mild, moderate, severe, or just about the worst discomfort you have ever suffered in your life?"

- 1 mild discomfort
- 2 moderate discomfort
- 3 severe discomfort
- 4 worst discomfort ever in life

PART B. TREATMENT

Interviewer: From abstracting form, circle any of the following treatments that were recommended.

- 1 SURGERY
- 2 PHYSICAL THERAPY
- 3 VOCATIONAL REHABILITATION

Then ask the question(s) below which correspond to the number of the recommended treatment(s).

1. a) "At the time of your visit you were recommended to get SURGERY. Were you able to do so?"

1. yes ---> IF YES, GO TO NEXT RELEVANT QUESTION OR PART C.

0. no

b) "If not, why not?" (Circle all that apply)

1 time

2 cost

3 denied by insurance

4 other reasons (specify) _____

2. a) "At the time of your visit you were recommended to get PHYSICAL THERAPY. Were you able to do so?"

1 yes ---> IF YES, GO TO NEXT RELEVANT QUESTION OR PART C.

0 no

b) "If not, why not?" (Circle all that apply)

1 time

2 cost

3 denied by insurance

4 other reasons (specify) _____

PART B, continued. TREATMENT.

Clinic ID Code _____

Patient ID Code _____

3. a) "At the time of your visit you were recommended to get VOCATIONAL REHABILITATION. Were you able to do so?"

- 1 yes ---> IF YES, GO TO PART C.
- 0 no

b) "If not, why not?" (Circle all that apply)

- 1 time
- 2 cost
- 3 denied by insurance
- 4 other reasons (specify) _____

PART C. OUTCOME/EMPLOYMENT

1. "Are you currently working?"

- 0 no ---> IF NO, GO TO QUESTION 3.
- 1 yes

2. "If yes, are you working full-time or part-time, light duty or regular duty?" (Circle one response from each column.)

- | | |
|-------------|----------------|
| 1 full time | 1 regular duty |
| 2 part-time | 2 light duty |

If working full time ---> GO TO QUESTION 4!

3. "Are you working less than full time because of your injury, the economy, or another reason?"

Please explain: _____

4. "Were any modifications made in your job to accommodate your conditions? What were they?"

4. "To what extent have your symptoms:

	Minor or Not at all Moderate	Major or Substantial
--	---------------------------------	-------------------------

- | | | | |
|---|-----|-----|------|
| a. Interfered with your leisure or household activities?" | [] | [] | []* |
| b. Caused you to change work assignments?" | [] | [] | []* |
| c. Caused a decrease in your work productivity?" | [] | [] | []* |
| d. Caused you to change the way you do your work tasks?" | [] | [] | []* |

* Explain: _____
