

## Guest Editorial

# The NIOSH Program for Evaluating Biomechanical Hazards in the Workplace

Daniel J. Habes and Vern Putz-Anderson

Twenty evaluations of reported biomechanical hazards were performed by the National Institute for Occupational Safety and Health (NIOSH) at the request of industrial workers or management over an 8-year period. The evaluations were part of the Hazard Evaluation and Technical Assistance (HETA) program authorized under the Occupational Safety and Health Act of 1970. A number of these evaluations are described here. Principles drawn from the field of ergonomics were used to evaluate whether a certain work activity has caused an observed incidence of cumulative trauma to the neuro-musculo-skeletal system. Procedures for conducting these ergonomic evaluations are reviewed, and the results are summarized. Recommendations are made for implementing control procedures, and the problem of obtaining reliable follow-up information is discussed. Project results suggest an encouraging degree of success in accomplishing prevention and control of biochemical hazards in the workplaces studied.

The National Institute for Occupational Safety and Health (NIOSH) conducts worksite evaluations of health hazards and provides

---

Daniel J. Habes and Vern Putz-Anderson are on the staff of the Applied Psychology and Ergonomics Branch, Division of Biomedical and Behavioral Science, National Institute for Occupational Safety and Health, Centers for Disease Control, Public Health Service, Department of Health and Human Services.

Special appreciation is extended to Dr. Donald Badger who, with the senior author, developed the original protocol for ergonomic HETAs, and who also served as one of the ergonomic specialists in 11 of the 20 worksite studies reported in this paper. Illustrations were drawn by Al Tudor based on adaptations of figures suggested by Thomas Armstrong. The editorial assistance of Anne C. Hamilton is also appreciated.

technical assistance in determining solutions to these occupational health hazards. This program is known as the Hazard Evaluation and Technical Assistance (HETA Program) and is a vital part of the Institute's activities in developing and establishing recommended occupational safety and health standards. Under the HETA program, an employer, three or more employees, an employee representative, or other governmental agency may request direct NIOSH assistance in determining the extent of possible health hazards in their workplace. The Occupational Safety and Health (OSH) Act of 1970 originally authorized this program only for investigation of potentially toxic substances in the workplace. The HETA program has now been broad-

ened to include technical assistance for physical and biomechanical hazards as well.<sup>1</sup>

This report describes NIOSH worksite evaluations that focus on biomechanical hazards posing a risk to the neuro-musculoskeletal system. The evaluations use the principles and practices of ergonomics to determine whether or not a certain work activity causes an observed incidence of cumulative trauma disorders. Depending on the nature of the request and the information supplied to document the problem, NIOSH may send a team of health professionals to conduct the evaluation. Environmental sampling, analysis of working conditions, review of medical records, and examination of workers may all be included in the evaluation.

Since 1972, NIOSH has conducted more than 2,000 hazard evaluations of all types, including toxic agents as well as physical and biomechanical hazards. Although the Institute is a research organization and has no enforcement authority, many recommendations for reducing hazards have been implemented.

The following sections review the procedures for conducting ergonomic evaluations of biomechanical hazards and summarize NIOSH experience in this particular area. Recommendations are made for implementing hazard controls, and the problems of obtaining reliable follow-up data are discussed.

---

## BACKGROUND

---

### Sources of Requests for Biomechanical Hazard Evaluations

In recent years, NIOSH has received a number of requests to evaluate musculoskeletal disorders stemming from biomechanical hazards (cumulative trauma). Such disorders are a code 7(f) entry on the Occupational Safety and Health Administration (OSHA) industrial health log (Form 200).

The first request for an ergonomic evaluation that cited either cumulative trauma or

repetitive motion as the hazard was filed with NIOSH in 1976. Since then and through mid-1984, NIOSH has responded to 20 requests for such worksite evaluations. Of these, 10 were initiated by employees or employee representatives, 3 were initiated by management, and the remaining 7 were joint labor and management requests.

The 20 requests received by NIOSH for ergonomic evaluations of biomechanical hazards may be classified by source as follows:

<u>Number of Requests</u>	<u>Source</u>
16	Companies engaged in light-to-medium manufacturing involving repetitive tasks
2	Food handling and processing companies
1	Company that transports and stores bulk commodities
1	Service and installation company

All but two of the 20 requests cited cumulative trauma disorders of the upper or lower extremity as the main health complaint. The two remaining requests originated from traditional heavy industries. They identified manual materials handling as the hazard and low back disorders as the health complaint. Table 1 lists the 20 completed hazard evaluations by industry or job type and the task of concern.

### Trends in Request for Biomechanical Hazard Evaluations

Indications are that requests for worksite evaluations identifying biomechanical demands as the suspected hazard will continue to occur and probably increase in the future. This prediction is partly reinforced by the considerable number of recent papers describing repetitive motion injuries to the hands and arms and reports of chronic fatigue associated with the neck, shoulders, and arms that are appearing in the scientific literature (Birbeck & Beer, 1975; Luopajarvi, Kuorinka, Virolainen, & Holmberg, 1979; Maeda, 1974; Vihma, Nurminen, & Mutanen, 1982).

In addition, a growing number of reports in the literature link musculoskeletal problems with certain work tasks for which compensation claims have been upheld (Hersherson, 1979; Hymovich & Lindholm, 1966;

---

<sup>1</sup>Hazard evaluations for physical trauma are not specifically mentioned under Section 20(a) (6) of the OSH Act as a subject for investigations at the workplace. Such authority is provided, however, in the Federal Mine Safety and Health Act of 1977 and is included within the definition of "physical agent" in the CFR for Requests for Health Hazard Evaluations, Part 85.2.

TABLE 1  
COMPLETED ERGONOMIC EVALUATIONS  
BY INDUSTRY AND TASK OF CONCERN

INDUSTRY OR JOB TYPE	TASK OF CONCERN
1. Film and paper manufacturer	Packaging of film and paper products
2. Tableware manufacturer	Inspection of finished glassware
3. Grocery warehouse	Handling and transporting of bulk quantities of grocery items
4. Laminated plastic products manufacturer	Trimming and packaging of finished molded plastic cups and bowls
5. Combustion exhaust systems manufacturer	Forming and assembly of chimney parts
6. Thermoformed fibrous glass-reinforced products	Finishing and sanding of fiberglass typewriter housings
7. Electrical extension cord manufacturer	Manufacturing, packaging, and inspection of electrical cord sets
8. Manufacturer of air filters	Fabricating metal frames for air filters
9. Manufacturer of electric generators	Wrapping layers of insulating tape around the coils of generators
10. Manufacturer of hand-held lubrication equipment	Fabricating and assembling parts for grease guns and bottle jacks
11. Resilient floor layers and decorators local union	Installation of wall-to-wall carpeting
12. Manufacturer of wholesale food products	Handling and transporting bulk ingredients for making food products and packaging finished items
13. Manufacturer of plumbing fixtures	Handling and transporting wet chinaware toilets for drying
14. Manufacturer of catalytic converters	Fabricating and assembling catalytic converter parts
15. Manufacturer of ammunition propelling charges	Handling and inspecting charges
16. Workwear garment manufacturer	Sewing together uniform pants and shirts
17. Fish fillet plant	Hand filleting and cleaning of fish
18. Publishing company/bindery	Handling bulk quantities of paper, feeding pages into machines, and packaging finished products
19. Publishing company/bindery	Handling bulk paper, trimming excess off printed pages, and feeding pages into machines
20. Small engine manufacturer	Fabricating and assembling parts for small engines

Jensen, Klein, & Sanderson, 1983; Kuorinka et al., 1979). One reason for this trend is that automation and job specialization have fragmented the worker's task so that a given job may involve only a few manipulations performed thousands of times per day. Moreover, as the average age of the workforce increases, so does the risk of developing osteoarthritis, which may be accelerated by repetitive patterns of usage.

#### PROCEDURES FOR ERGONOMIC EVALUATIONS OF HAZARDS

##### Initial Evaluation of the Problem

Before a worksite visit, an investigative team is assembled to review the HETA request and determine the appropriate response strategy. The requested evaluations that clear-

ly document work processes, biomechanical hazards, and accompanying health problems, and that also appear amenable to intervention through basic job or tool redesign, may often be resolved after a single worksite visit. This possibility is illustrated by a recent request for an evaluation that identified repetitive wire wrapping by electronic assembly workers as the main source of biomechanical stress to the wrist. Carpal tunnel syndrome and other disorders were the complaints. Since this kind of problem had been encountered before, the investigative team could avoid a major job analysis and focus on developing a practical solution. In this case, the team recommended the use of a fixture for securing the wire and substitution of a plastic wire wrap for electrical tape to eliminate repetitive wrist motions.

In contrast, NIOSH recently received a re-

quest to evaluate workers who used microscopes in a major part of their work and who reported musculoskeletal disorders of the neck and upper trunk. Here the nature of the biomechanical hazards and symptoms were not well documented in the literature or well understood by ergonomists. As a result, the first step was to conduct a full-scale, retrospective case-control study to sort out the major stress-producing elements in such work and their association with health complaints. In addition, a separate ergonomic assessment of microscopist workstations is now being undertaken to define optimum design features and alleviate the health problems. Most requests to NIOSH fall somewhere between these two extreme cases, however.

As information on new ergonomic problems is accumulated and appropriate interventions are developed, the investigative team can increasingly draw on existing ergonomic guidelines and avoid some of the more time-consuming data collection. This philosophy has been the guiding force of the ergonomic evaluations completed to date. As a result, NIOSH has been able to resolve 13 of the 20 ergonomic evaluations after a single 8-hour worksite visit.

### Subsequent Stages of Problem-Solving

Regardless of their complexity, most of the NIOSH HETA activities involving ergonomic problems evolve through a sequence of three stages: (a) identifying and defining the potential hazard and health effect, (b) analyzing jobs to link the suspected biomechanical hazard with an adverse health effect, and (c) developing recommendations for interventions to control or prevent the health risk. A description of each stage follows.

*Identifying potential hazards.* At the outset, some estimate is needed of the nature and incidence of the alleged health problem. Such data can help select the jobs for ergonomic analysis and establish a baseline for evaluating improvements from any subsequent interventions. The following information is sought:

1. The total number of cumulative trauma disorders reported;
2. The date each case was reported;

3. The department and preferably the specific job of the injured worker; and

4. The number of workers on the same job or in the same department.

The OSHA Form 200 logs are initially reviewed for indications of repeated trauma disorders, which are reported on Column 7(f). The plant's accident records, as contained in OSHA Form 101, may also be scrutinized. Although these records are not designed for identifying cumulative trauma disorders, an accident may indicate an extreme condition. For example, chronic overexertion creates excessive wear and tear that increases the worker's risk of an acute injury. Hence, jobs connected with these injuries are considered potential candidates for interventions to reduce the risk of overexertion before acute injury.

If payroll records are available, they can be used to determine the number of hours the workforce or specific group has been exposed to a particular hazard. Jobs and departments with a high turnover or excessive absenteeism can also be determined from such records.

Medical records of some form were available for inspection in all but one of the 20 ergonomic evaluations done by NIOSH. OSHA logs were inspected during 9 of the 20 evaluations. Information from payroll records was not so readily available or so easily interpreted. As an alternative, some employers provided an estimate of exposure hours. For most ergonomic evaluations performed to date, the investigative team has been satisfied (based on the data available) that a work-related musculoskeletal problem existed as noted in the original HETA requests.

The incidence rates for cumulative trauma disorders were computed for specific jobs in 15 of the completed evaluations. The injury or disorder rate for various worksites ranged from a low of 3% to a high of 58%. Plant-wide incidence rates ranged from 2.0 cases per 100 man-years to a recent high of 25.6 cases. Of the 20 worksite evaluations completed, 12 had employees who had been diagnosed and treated for one or more cases of cumulative trauma injury, including carpal tunnel syndrome. These figures were computed specifically for those jobs in each plant that showed evidence of biomechanical trauma.

The above data reflect only the past occurrences or complaints of cumulative trauma disorders and may not, therefore, give an accurate picture of the present situation. To remedy this, a medical survey or questionnaire may be used to obtain more current information on the prevalence rates. The questionnaire is also used to identify areas or jobs with potential for cumulative trauma disorders; it is not used to obtain a detailed assessment of the disorders.

Although the questionnaires are easy to administer, the information obtained is subject to bias if the instrument is not constructed properly (Berdie & Anderson, 1974). The complexity of the wording, the length, the instructions used, and the time and method of administration (oral versus written) must be considered. Despite the problems, surveys provide a quick method for identifying worker's perceptions of hazards and sources of physical discomfort.

Self-administered or written questionnaires have been used in only 4 of the 20 ergonomic cases completed by NIOSH. Most of the NIOSH investigators performing ergonomic research prefer to use a semi-structured oral interview. A main advantage of the oral interview over the written is that a skilled interviewer can readily adapt the line of questions to fit the worker's understanding of the problem. Moreover, workers can be interviewed at the job site, and the information obtained is immediately available to target certain jobs for more in-depth ergonomic analysis.

A medical screening technique can also be used for a clearer picture of the nature and severity of the health complaints. This approach is particularly useful when the reported symptoms suggest the preclinical stage of disease and when there are still few documented cases of musculoskeletal disorders. Trained medical personnel can perform relatively simple examinations of workers to provide a more accurate picture of the nature and severity of problems that exist.

*Analyzing jobs.* The purpose of the job analysis is to determine the relationship between work patterns and musculoskeletal impairment. Examples of task that have been ana-

lyzed by NIOSH investigators appear in Table 1. They include assembling, packing, trimming, sanding, winding, drilling, and sewing. Methods for conducting job analyses are described by Armstrong, Foulke, Joseph, and Goldstein (1982) and Konz (1979).

NIOSH investigators usually confine their ergonomic analyses to three major areas: work methods, work station design and worker posture, and handle and tool design. Each area of analysis is discussed here briefly.

1. *Analysis of work methods*—The concern in analyzing work methods is to determine what the worker must do to perform the task successfully. Such a determination requires recording arm and hand positions, computing the number of repetitive movements in a given work cycle, and measuring or at least estimating the forces required by the job. In the cases of hand and wrist disorders, suspected problematic postures are noted and documented. Figure 1 illustrates the hand and wrist postures that contribute to cumulative trauma injuries of the hand. The neutral position is the least stressful.

The organization of the work is also noted along with the duration of a task cycle. The amount of time an extremity is maintained in a certain stressful posture is very important because stress on the structure accumulates. Also to be considered are the speed, intensity, and pace at which the worker must perform to meet production or quality standards.

The adverse effects of excessive production standards were illustrated at a warehouse that had requested a worksite evaluation. The request was based on the high incidence of overexertion injuries (chiefly back disorders) from lifting tasks. The job analysis indicated that these injuries were caused by a combination of excessive lifting task demands and production standards that exceeded the strength and endurance capabilities of 33% of the workforce.

2. *Analysis of the workstation*—In conducting the worksite evaluations, the ergonomic investigators examine the relationships between worker and workstation features, such as sitting versus standing, and other postural factors. These elements are closely interrelated, so that stress caused by one element results in stress on the other.

FIGURE 1  
 DEVIATED POSTURES THAT CAN LEAD  
 TO HAND AND WRIST DISORDERS

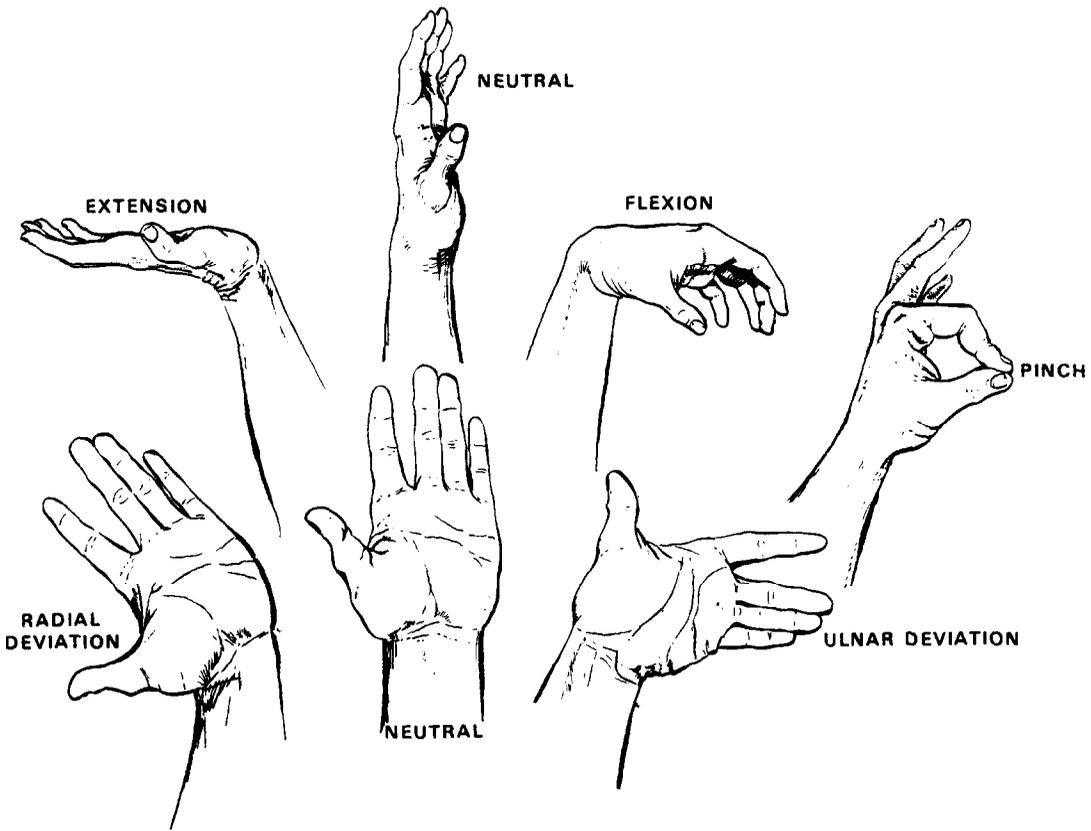


Figure 2 illustrates a situation that can cause biomechanical stress through faulty workstation design. The worker shown is subject to muscular overload of the arm and wrist from lifting and inspecting each item to locate an identifying code that is entered into a register. The worker may also have to assume awkward bending posture to retrieve items from an input tray. This same workstation may also impose static muscular constraints from prolonged standing. Moreover, the height and orientation of the input register determines the amount of wrist extension required to enter the data. The surface and slant of the counter also determines the position of the elbow and shoulder as well as the amount of force exerted to move the items.

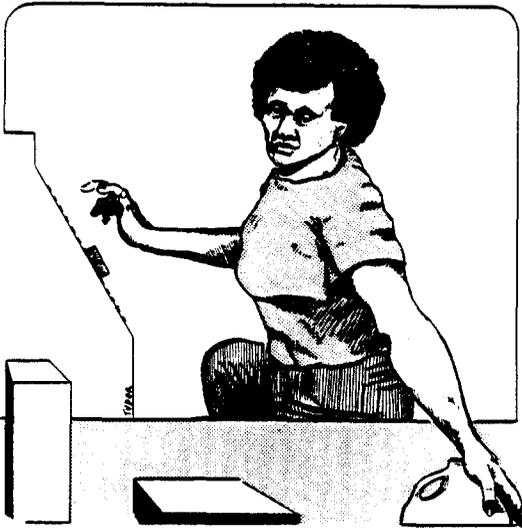
In this workstation example, the task of repeated high-force gripping has been shown to irritate the tendinous attachments of the

finger flexor muscles on the inside of the elbow. Likewise, shoulder disorders such as rotator cuff irritation and bursitis are associated with elbow positions elevated above mid-torso height. These disorders are often exacerbated by the design of a workstation that either fails to fit the worker because of lack of adjustment or is improperly designed with respect to the repetitive nature of the work activity.

3. *Analysis of handle and tool designs*—Another aspect of the evaluation concerns the design and use of the hand-held tools and the type of equipment controls available to perform the task. NIOSH investigators have observed more cases of faulty tool design in their evaluations than any other ergonomic factor.

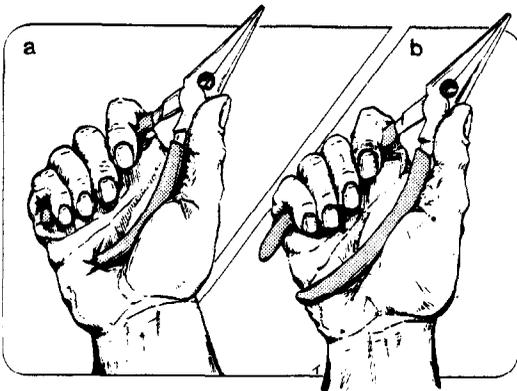
A common problem is illustrated in Figure 3a. The handle of the tool is too short for the worker's hand. Such tools may inflame wrist

FIGURE 2  
EXAMPLE OF A WORKSTATION  
THAT CAN CAUSE BIOMECHANICAL  
STRESS THROUGH FAULTY DESIGN



tendons, obstruct the flow of blood in the palm, and necessitate the use of weaker muscles. Constant pressure may also cause obstruction of the blood flow to hand or fingers and increase the strain on the tendons and tendon sheaths. Tools that are supported in

FIGURE 3  
EXAMPLES OF FAULTY (a) AND  
IMPROVED (b) TOOL HANDLE DESIGN



Note. — A tool handle supported over the base of the palm (a) can create continuous pressure on the soft tissues of the hand. The improved handle (b) distributes grip forces over the muscular eminences on either side of the palm.

the hand should be long enough to distribute the forces over the muscular areas at the base of the thumb and little finger (Figure 3b). Armstrong (1984) has documented a series of stressful tool postures and provided numerous suggestions for redesign to alleviate biomechanical stress.

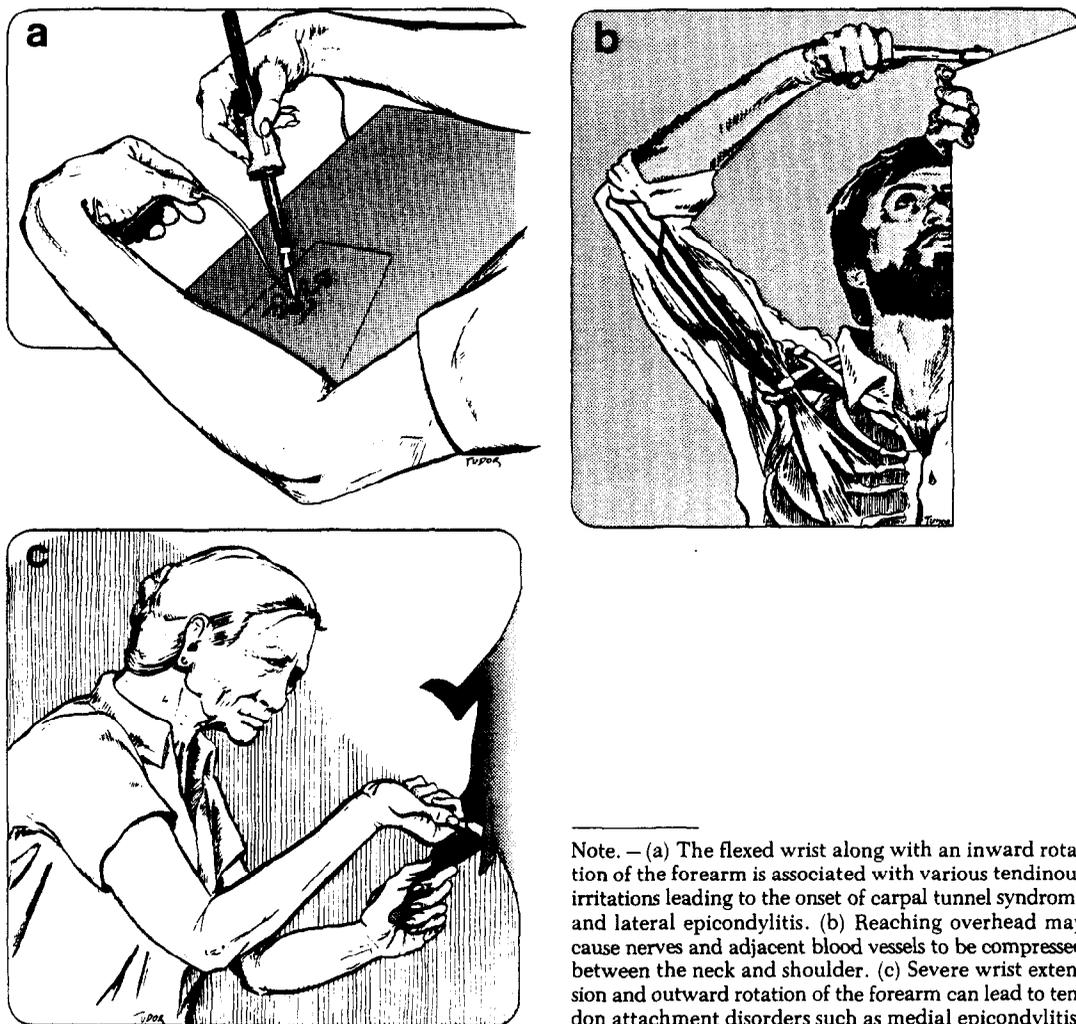
A variety of potential sources of biomechanical stress exist in the workplace. The three most common sources are work methods, workstations, and tools and controls. Other sources of potential biomechanical stress include the amount of clothing and type of personal protective equipment used by the worker. Because of the complexity and number of factors that must be considered in a worksite evaluation, ergonomists are developing special checklists to ensure that all stressful aspects of the man-machine relationship are reviewed and readily recorded. A number of these checklists are being used by NIOSH investigators. Examples appear in Grandjean (1981, pp. 351-355) and have been published by the National Safety Council (1983, pp. 33-41). Drury (1982) has developed an ergonomic checklist that can be fed into a computer to measure job risk and to suggest simple interventions.

In addition to checklists, the NIOSH ergonomists use a combination of 35 mm still photographs and video tapes of 8 mm movies to record the key components of the work process where biomechanical trauma is evident. The recordings are taken back to the laboratory for detailed analysis before recommendations are made for control.

NIOSH investigators have reviewed the results of the ergonomic evaluations conducted to date on the upper extremity to determine whether jobs in which workers were experiencing problems showed a consistent pattern of upper extremity biomechanical trauma. The most common finding was that high-risk jobs had high rates of manual repetition combined with deviated wrist postures. Figure 4 shows examples of the most common biomechanical hazards identified during the NIOSH evaluations. They include excessive wrist flexion and extension, reaching overhead, pinch gripping, and use of wrist/arm torque.

*Developing recommendations for interventions.* Recommendations consist of prescrip-

FIGURE 4  
EXAMPLES OF THE MOST COMMON BIOMECHANICAL HAZARDS  
IDENTIFIED DURING NIOSH HETA EVALUATIONS



Note. — (a) The flexed wrist along with an inward rotation of the forearm is associated with various tendinous irritations leading to the onset of carpal tunnel syndrome and lateral epicondylitis. (b) Reaching overhead may cause nerves and adjacent blood vessels to be compressed between the neck and shoulder. (c) Severe wrist extension and outward rotation of the forearm can lead to tendon attachment disorders such as medial epicondylitis.

tive statements defining a course of action for preventing or reducing biomechanical trauma. Two basic approaches are used to achieve control: administrative and engineering.

1. *Administrative controls*— Recommendations on the use of supervisory practices to limit exposure to biomechanical trauma are labeled as administrative. Examples of this include worker training, matching employees to job demands, and job rotation.

Although job rotation can effectively reduce the exposure time of individual workers

to tasks that call for stressful postures of the arm, wrist, and hand, it also poses an increased hazard of traumatic injury. A main reason is that the worker may lack experience with the rotated jobs and suffer response interference. The interference is often the result of the transfer of an inappropriate response from a former job to the next job. An example of this was observed in a feed processing plant where workers could rotate from filleting to trimming operations. Both jobs required the use of a knife, but the former required high force,

and the latter required small articulated motions. Workers who rotated between the two jobs had difficulty adjusting to the different force requirements of the task. Consequently, they often overcut or undercut. Apart from chronic trauma considerations, these tendencies also increase the worker's risk of suffering severe finger or hand cuts.

A main advantage of administrative control procedures is that they are often easily implemented and may be less costly (at least initially) than engineering controls. The disadvantage is that they treat the symptoms and not the causes of biomechanical stress. Since biomechanical trauma is often an intrinsic byproduct of performing a job, the most effective control is to redesign the job.

2. *Engineering controls*—Engineering controls are concerned with redesigning the job to alleviate sources of biomechanical trauma. Many of the principles used in redesigning jobs and tools are drawn from the field of ergonomics. Unlike that in administrative controls, *the guiding principle for ergonomics is to make the job fit the person, not to make the person fit the job.*

The object of ergonomics is difficult to accomplish cost-effectively for most workplaces. A main reason is that overlapping sources of biomechanical stress may contribute in some unknown manner to the onset of musculoskeletal disorders. Hence, there is usually no simple single change to be made. Numerous adjustments may be required in tailoring recommendations to the tool, workstation layout, or organization of the work process.

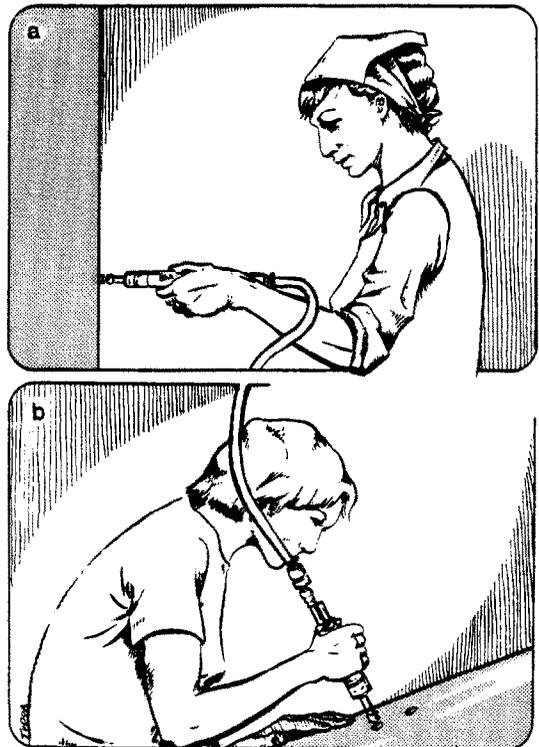
Another complicating factor is that significant differences exist between various types of work environments (industrial, retail, and office). A recommendation that is effective in one setting may be inappropriate or unnecessarily costly for another. The final caveat is that ergonomics is not an exact science, and experts still disagree on the effectiveness of many aspects of engineering controls. Despite these difficulties, a pressing need exists to develop practical engineering controls for jobs on which workers have experienced musculoskeletal strain.

*Examples of interventions.* A majority of the NIOSH recommendations developed in response to the HETA requests consisted of pre-

scriptions for engineering controls (i.e., tool and task redesign). Three examples follow that illustrate various approaches for controlling cumulative trauma injuries to the upper extremity.

The first example is concerned with the use of an improperly designed tool causing the wrist to bend too far. This is illustrated in a metal assembly job (Figure 5). Wrist deviation was required to use an in-line air wrench against a vertical surface. One option suggested for controlling this posture is shown in Figure 5b. By repositioning the perpendicular work surface to a 25° orientation from the horizontal, the worker could hold the tool against the work surface without having to bend the wrist. Other options exist such as elevating the worker's position or changing

FIGURE 5  
MACHINE ASSEMBLY JOB WITH  
(a) ULNAR DEVIATION AND  
(b) NEUTRAL WRIST POSITION



Note.—Neutral wrist position in (b) is achieved by reorienting work surface.

the shape of the handle. As a general rule, tools or tasks should be designed so that the wrist is maintained in the neutral position (Figure 1).

A second example of a common problem encountered in the workplace involves a layout of the workstation or placement of controls that forces a worker to reach too far. Figure 6a illustrates an extreme reach requirement observed in a sheet metal stamping job. This awkward, static position contributed to shoulder fatigue. Though not evident in the illustration, this particular task required the operator to turn the controls, causing a moderate ulnar deviation of each hand. An example of an improved control layout is shown in Figure 6b.

The last example involves a combination of biomechanical stresses resulting from job de-

mands. They include a flexed wrist position, repeated movements, and significant grip force. This problem was encountered in an evaluation conducted at a plant that manufactures fiberglass typewriter housings. Figure 7a shows a worker with a flexed wrist sanding the edges of the housing. Wrist flexion combined with the considerable force required to maintain the grip on the power sander contributed significant amounts of biomechanical strain to the wrist structures. Some of the ergonomic recommendations that were developed for this job are shown in Figure 7b. They include the use of an adjustable fixture to hold and orient the housing and pistol-type handles for the files and sander to eliminate excessive wrist flexion. This handle design was inspired by a NIOSH-funded study of hand tool configurations for controlling wrist disorders in a high-risk work situation (Armstrong et al., 1982).

Although the above examples of engineering redesign follow the principles of ergonomics, their actual application must be customized to the particular job or task under evaluation. Such efforts can require real creativity.

#### Dissemination and Follow-up

To conclude an evaluation, a report is prepared that includes the investigative team's findings on the nature of the biomechanical hazard, the degree of musculoskeletal impairment associated with the hazard, and the methods used to analyze the jobs. But the most important part of the report lists recommendations for prevention and control. Copies of the final report are supplied to both employers and representatives of the employees.

A year or 18 months after the report is released, a member of the investigative team will contact the company to determine its progress in alleviating the problem. A main concern is whether any of the recommendations have been implemented and, if so, what the outcome has been.

The results from this follow-up activity at NIOSH have been mixed. Recommendations have been implemented in 8 of the 20 work-sites studies. For the remaining 12 evaluations, reliable follow-up information has not been obtained. Of these twelve evaluations,

FIGURE 6  
EXAMPLES OF FAULTY (a) AND  
IMPROVED (b) CONTROL LOCATIONS



Note. — Location of controls in (a) forces operator to use extreme shoulder elevation as well as flexed wrists with moderate ulnar deviation of both hands. An improved layout is shown in (b).

FIGURE 7  
EXAMPLES OF FAULTY (a)  
AND IMPROVED (b) LAYOUTS  
FOR SANDING OPERATIONS



Note. — Worker in (a) must flex wrist and exert sufficient force to hold sander against horizontal housing. The improved layout (b) incorporates an adjustable fixture for holding and orienting the housing and an improved handle design for the sander.

however, five were completed within the past year and are probably still being reviewed by the company.

Quantifiable data illustrating the effectiveness of the recommendations are available from only two of the evaluations. The best example comes from a plant where hand-held lubrication equipment is manufactured and assembled. In this instance, a 17% reduction occurred in the number of injuries related to the jobs under investigation in the year following implementation. Lost work time was reduced by 62%, and the number of cases of carpal tunnel syndrome was reduced from 8 to 1 during the same time period. Moreover,

costs related to payment of claims were reduced by 40%.

The second example comes from an evaluation conducted at a worksite where molded plastic containers were produced. Trends similar to the first example were found in the period following implementation. The highlight was a reduction in the number of cumulative trauma injuries from a high of 19 to a single case. As one might suspect, the companies whose management was actively involved in requesting the evaluations have been more active in implementing the recommendations.

## CONCLUSIONS

The most problematic aspect of this program may be the difficulty in obtaining useful follow-up information on the effectiveness of the interventions. Several reasons for this deficiency can be cited. Foremost is that NIOSH recommendations are just that — recommendations. The requester is free to reject any or all of the suggestions. Nevertheless, members of the investigative teams have informally been told by various requesters that many of the ergonomic recommendations have been adopted.

In addition, industry is reluctant to provide specific examples or data concerning the effectiveness of the recommendations. The concern is that such revelations may be interpreted as an admission by management that workers were exposed to hazardous conditions that required Federal intervention to rectify. Such an admission may be viewed in a future litigation as grounds for worker disability claims based on past exposure to hazardous physical stress.

For many evaluations it has been difficult to assess directly the effectiveness of the NIOSH ergonomic recommendations. Nevertheless, a number of indirect effects have suggested a degree of success in accomplishing prevention and control. Perhaps the most positive indirect effect of NIOSH involvement has been to increase industry's awareness of methods for effecting injury control. Some companies have taken a much more radical approach than that proposed in the initial NIOSH recommendations. For example, when two industries were faced with implementing

basic job or tool changes, they used the occasion to implement a complete overhaul or major renovation to eliminate those jobs or tasks judged as hazardous. In other cases, the companies have complied with the intent of the recommendations by improving the overall quality control and thereby eliminating most of the repetitive finishing and handling processes. Many of these actions were much more ambitious, and initially more costly, than the recommendations for job and tool redesign offered by the NIOSH investigative team.

Although these companies did not follow the specific NIOSH recommendations, they have accomplished the objective. Furthermore, these companies have acknowledged that as a result of supportive involvement by NIOSH, both worker health and the economics of the situation have improved. Hence the NIOSH ergonomics program directed at reducing musculoskeletal injuries and disorders has succeeded through a combination of direct interventions and a more general process of creating or reinforcing an awareness of problems and the need for creative solutions.

---

## REFERENCES

- Armstrong, T. J., Foulke, J. A., Joseph, B. S., & Goldstein, S. A. (1982). Investigation of cumulative trauma disorders in a poultry processing plant. *American Industrial Hygiene Association*, 43(2), 103-116.
- Berdie, D. R., & Anderson, J. F. (1974). *Questionnaires: Design and use*. Metuchen, NJ: The Scarecrow Press.
- Birbeck, M. Q., & Beer, T. C. (1975). Occupation in relation to the carpal tunnel syndrome. *Rheumatology and Rehabilitation*, 14, 218.
- Drury, C. G. (1982). Personal Communication. Suny at Buffalo, NY.
- Grandjean, E. (1981). *Fitting the task to the man: An ergonomic approach*. London: Taylor and Francis Ltd.
- Hersherson, A. (1975). Cumulative Injury: A national problem. *Journal of Occupational Medicine*, 21(10), 674-676.
- Hymovich, L., & Lindholm, M. (1966). Hand, wrist and forearm injuries, the results of repetitive motions. *Journal of Occupational Medicine*, 8(11), 575-577.
- Jensen, R., Klein, B., & Sanderson, L. (1983, September). Motion-related wrist disorders traced to industries, occupational groups. *Monthly Labor Review*, pp. 13-16.
- Konz, S. (1979). *Work design*. Columbus, OH: Grid Publishing.
- Kuorinka, I., & Koskinen, P. (1979). Occupational rheumatic diseases and upper limb strain in manual jobs in a light mechanical industry. *Scandinavian Journal of Work Environment and Health*, 5(Suppl. 3), 39-47.
- Luopajarvi, T., Kuorinka, I., Virolainen, M., & Holmberg, M. (1979). Prevalence of tenosynovitis and other injuries of the upper extremities in repetitive work. *Scandinavian Journal of Work Environment and Health*, 5(Suppl. 3), 48-55.
- Maeda, K. (1975). Occupational cervicobrachial disorder and its causative factors. *Journal of Human Ergology*, 6, 193-202.
- National Safety Council. (1983). *National Safety Council ergonomics guidebook*. Chicago: Author.
- Oja, P., Seppala, P., Louhevaara, V., Lehtonen, A., & Hakkanen, S. (1978, September). Job demands, musculoskeletal strain and subjective well-being at different levels of mechanization in the Finnish sawmill industry. In *Abstracts (XIII) International Congress of Occupational Health* (p. 438). Dubrovnik, Yugoslavia.
- Vihma, T., Nurminen, M., & Mutanen, P. (1982). Sewing-machine operators' work and musculoskeletal complaints. *Ergonomics*, 25(4), 295-298.