ELSEVIER

International Journal of Industrial Ergonomics 21 (1998) 47–58

International Journal of
Industrial
Ergonomics

The effectiveness of participatory ergonomics in the red meat packing industry Evaluation of a corporation

J. Steven Moore[a,*], Arun Garg[b]

[a] *Department of Occupational Health Sciences, University of Texas Health Center at Tyler, P.O. Box 2003, Tyler, TX 75710-2003, USA*
[b] *Department of Industrial and Systems Engineering, University of Wisconsin-Milwaukee, P.O. Box 784, Milwaukee, WI 53201, USA*

Received 29 December 1995; received in revised form 12 June 1996; accepted 26 December 1996

Abstract

This investigation evaluated the effectiveness of a corporate ergonomics program that used a participatory approach to solving problems related to musculoskeletal hazards. This meat products corporation developed and implemented a structured, centrally managed participatory ergonomics program in 1986. In the years following implementation, the corporation experienced an increase in the crude incidence rate; a significant decrease in the percentage of recordable disorders related to musculoskeletal risk factors; a marked decrease in the lost-time incidence rate; and a marked decrease in total and per capita annual workers' compensation costs. These results were consistent with the inference that an ergonomics program that uses a participatory approach to identifying and solving problems in the red meat packing industry may be effective in reducing the severity of musculoskeletal morbidity and workers' compensation costs.

Relevance to industry

If a company implements an ergonomics program that incorporates employee participation, what changes in injury/illness statistics and workers' compensation costs might be anticipated? Will incidence rates go up or down? Will costs related to workers compensation claims increase or decrease? This paper presents such information from one corporation. It provides data for estimating the direction and magnitude of such effects for a new program as well as data for benchmarking an existing program.

Keywords: Participatory ergonomics; Ergonomics programs; Workers' compensation costs; Meat products industry; Program evaluation

1. Introduction

During 1992–1993, a corporation involved in red meat packing participated in a demonstration project sponsored by the US National Institute for Occupational Safety and Health (NIOSH). The purpose of the project was to evaluate the effectiveness of the participatory approach to solving ergonomics problems in that industry. The methods and results for the entire project were published as part of a NIOSH document (Moore

* Corresponding author. Tel.: (903)877-5900; fax: (903)877-7982.

PII S0169-8141(97)00024-3

and Garg, 1994a). The project had two major components. The component reported in this paper involved describing the historical development and implementation of the corporation's ergonomics program and presenting descriptive information related to evaluating this program's effectiveness across the entire corporation. Similar results describing the effectiveness of the program within one of the corporation's pork slaughtering and processing plants have been presented elsewhere (Moore and Garg, in press). The other component of the project involved working with two ergonomics teams in the slaughtering and processing plant to identify problems and develop solutions for targeted jobs. Description of the problem-solving process used by the teams and its application to three jobs as well as feedback from members of the teams have been published elsewhere (Moore and Garg, in press; Moore and Garg, 1996).

The red meat packing industry has been associated with an increased prevalence and incidence of upper extremity disorders. The National Institute for Occupational Safety and Health (NIOSH) observed that the prevalence of symptoms and/or physical findings of upper extremity disorders among workers performing varied meat packing tasks ranged from 21% to 83% (NIOSH, 1989). Finnish investigators also reported increased prevalence of tension neck and peritendinitis or tenosynovitis in the distal upper extremity among meat packing and meat processing workers (Viikari-Juntura, 1983; Viikari-Juntura et al., 1991). Kurppa et al. (1991) reported an increased incidence rate of epicondylitis and tenosynovitis among meat cutters, sausage makers, and packers compared to controls (Kurppa et al., 1991). Moore and Garg noted a statistically significant increased risk of developing a distal upper extremity disorder among workers performing 'hazardous' tasks in a pork processing plant (Moore and Garg, 1994b). Several investigators have also reported an association between carpal tunnel syndrome (CTS) and meat packing or meat processing work (Falck and Aarnio, 1983; Masear et al., 1986; Moore and Garg, 1994b). Masear et al. (1986) noted that, on average, one case of CTS (one hand) was associated with 53.6 d away from work, $1848 in workers' compensation costs, and $8073 in settlement costs during the five year period preceding 1983 (Masear et al., 1986).

As described by Habes, a variety of circumstances brought significant changes to this industry in the US in the early 1980s, e.g. higher production rates, machine pacing, and task specialization (Habes, 1994). In the late 1980s, the US meat packing industry's incidence of 'disorders due to repeated trauma' was reported to be approximately 75 times higher than the average for US industries as a whole (Sheridan, 1991). According to data from the Bureau of Labor Statistics (BLS), the annual crude incidence rates (total injuries and illnesses per 100 workers per year) between 1976–1994 (inclusive) for US private industry (SIC-0000) and the US meat products industry (SIC-2010) were fairly constant, but the rates for the meat products industry were approximately three times higher than private industry (Fig. 1). The annual lost-time incidence rates (injuries and illnesses with at least one lost or restricted work day per 100 workers per year) were also fairly constant for US private industry and the US meat products industry during this time period, but the rate for the US meat products industry was approximately four times higher than general industry (Fig. 2). In 1987 and 1988, the US. Occupational Safety and Health Administration (OSHA) levied unprecedented fines on two of the largest US meat packing companies based, in part, on these increased incidence rates. As part of their 'settlement agreements', they agreed to implement ergonomics programs. In 1990, OSHA published its *Ergonomics Program Management Guidelines for Meatpacking Plants* (OSHA, 1990). This document recommended a participatory approach, especially worker involvement.

A review of the literature revealed no published papers that described the effectiveness, or lack thereof, of an ergonomics program in the red meat packing industry, including the 'settlement agreement' programs mentioned above. Three studies in nonmeat packing industries reported pre-intervention versus post-intervention comparisons of injury/illness data (Garg and Owen, 1992; McKenzie et al., 1985; Moore, 1994). They reported modest decreases in incidence rates and marked decreases in measures of severity, e.g. severity or lost-time incidence rates.

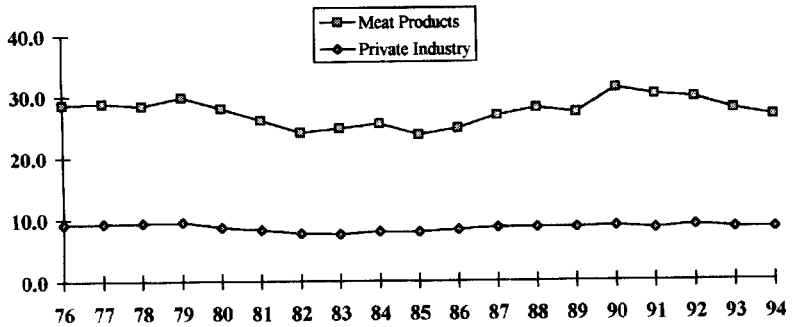

Fig. 1. The annual crude incidence rates (total number of recordable injuries and illnesses per 100 workers per year) for all US private industry and the US meat products industry for years 1976–1994 (BLS, 1996).

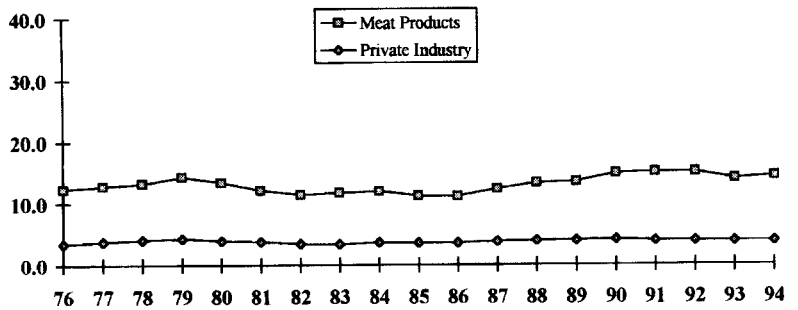

Fig. 2. The annual lost-time incidence rates (total number of recordable injuries and illnesses with at least one day of lost or restricted work per 100 workers per year) for all US private industry and the US meat products industry for years 1976–1994 (BLS, 1996).

2. Background

2.1. The corporation

The corporation participating in this study was founded in the United States in 1891. The corporation and its subsidiaries manufacture, market, and distribute thousands of meat products worldwide, including sausages, hams, wieners, bacon, canned luncheon meats, shelf-stable micro-wavable entrees, stews, chilis, hash, meat spreads, and frozen processed products. The corporation has two plants in the United States that slaughter and process pork. Other meat and food products manufacturing facilities are located throughout the United States. Internationally, the corporation has operations in the Philippines, Japan, Korea, England, and other European countries.

The corporation is owned by approximately 10 500 stockholders and employs approximately 11 000 people. In 1993, the corporation posted earnings of $105 million based on sales of $2.85 billion prior to a one-time accounting adjustment.

Historically, production employees have been represented by organized labor. Employees first organized as a union in 1933, forming the Independent Union of All Workers No. 1. The name of the union changed over the years as a result of affiliations and mergers. Since the late 1970s, the plant workers have been represented by the United Food and Commercial Workers Union (UFCW), AFL-CIO.

In terms of employee benefits, the corporation established guaranteed annual wage for its production workers in 1933. This program guarantees all workers a minimum annual wage based on 36 h per

week, even if the actual number of hours worked was less. The company established a Joint Earnings Plan, a profit sharing plan for all employees, in 1938. This plan is guaranteed and allows workers with 30 yr of seniority, regardless of age, to retire with no reduction in benefits. For years, the corporation used an incentive system to determine worker wages. In 1978, the corporation and the UFCW reached agreement that led to the ultimate discontinuance of the incentive pay system that had been in effect for 41 yr for union workers.

2.2. The corporate ergonomics program

The corporation began development and implementation of its Ergonomics Program in 1986. Three factors contributed to the company's awareness of the need for an ergonomics program: (1) OSHA citations of other red meat packers; (2) media attention; and (3) a corporate evaluation of workers' compensation costs. The proposed goal of the program was to:

Establish a company-wide employee-involved continuing program to:

1. reduce the amount of physical stress in the workplace,
2. prevent internal damage to the body, and
3. reduce the cost of work-related injuries and illnesses.

This program was developed primarily by a Corporate Ergonomics Coordinator. This person is an industrial engineer with more than 45 yr experience in the meat packing and processing of pork. Even though the corporate Ergonomics Program started in 1986, the written program was not completed and distributed to all company personnel until 1992. One reason for this delay was a decision to use the OSHA *Ergonomics Program Management Guidelines for Meatpacking Plants* as a template for the formal written corporate program (OSHA, 1990).

In terms of structure, the corporation uses a Corporate Steering Committee to authorize, guide, and support all ergonomics-related activities. The members of this committee include the Vice President for Engineering; the Corporate Counsel; the Vice President of Beef and Pork Operations; the Director of Industrial Engineering; Corporate Safety and Security Manager; the Group Vice President for Operations; and the Corporate Ergonomics Coordinator. The Corporate Steering Committee communicates to individual ergonomics committees within each plant via the management of the plant. This is done to ensure supervisory as well as employee participation.

The following sections briefly describe the corporation's Ergonomics Program and its implementation. For more detail, the reader is referred to the complete report in the NIOSH document (Moore and Garg, 1994).

2.3. Management commitment

In 1986, the Chairman, the President, and the Chief Executive Officer of the corporation formalized the company's policy on the issues of safety, health, and ergonomics. This Safety, Health, and Ergonomics Policy focuses on four key elements:

1. the corporation is concerned about employees' continued health and safety,
2. the corporation is committed to the implementation and maintenance of effective safety, health, and ergonomics programs and to the promotion of these programs through employee participation, awareness and education,
3. through each plant's established committees and programs on safety, health, and ergonomics, the employees are encouraged to participate and provide input to develop and maintain a safe and effective workplace,
4. the safety, health, and ergonomics programs are, and must continue to be, an integral part of all of the corporation's operations.

2.4. Employee involvement

The corporation is committed to employee involvement. Methods to achieve this objective include:

1. the use of employee surveys, questionnaires, and suggestion procedures in a spirit of cooperation and mutual benefit,
2. the use of procedures that endorse prompt and accurate reporting of signs and symptoms (use of an educational videotape and booklet about

signs and symptoms, ergonomics, and participation; an encouraging letter from the Corporate Steering Committee; and re-emphasis during the training program),
3. interaction with other quality, safety, and health committees,
4. training of all members of each ergonomics committee to develop ergonomic skills (this training is coordinated and given by the Corporate Ergonomics Coordinator).

2.5. Program elements

The corporation's Ergonomics Program closely parallels the OSHA Red Meat Packing Guidelines (OSHA, 1990). There are four major sections.

2.5.1. Workplace analysis

The corporation uses its own forms and checklists, injury/illness data, and workers' compensation expense data to target jobs for more detailed analysis. Aside from identifying existing problems (retrospective intervention), this method also allows the ergonomics committees to become involved in planned changes, such as new facilities, processes, materials, or equipment (prospective intervention and design).

2.5.2. Hazard correction, prevention, and control

The corporation uses the following procedure for hazard correction:
1. Targeted corrections are listed.
2. Priorities for corrections are established.
3. Individual assignments are made (e.g. the industrial engineer is to contact a manufacturer to obtain some equipment within one week).
4. Action is initiated.
5. Progress is monitored.
6. Problems that arise are solved.
7. Accomplishments are recorded.
8. Corrected status is maintained.
9. Successes are shared with other plants.

In terms of prevention and control, the corporation relies on the four traditional techniques of exposure control: engineering techniques, work practice controls, personal protective equipment, and administrative controls. The corporation prefers engineering solutions and believes that engineering techniques are best done during design or modification of work stations, work methods, or tools.

2.5.3. Medical management

The medical management component of the corporation's Ergonomics Program is described as 'a conscientious attempt to eliminate the risk of development of cumulative trauma disorder signs and symptoms through early identification and treatment and to the prevention of future problems'. This component includes the availability of first aid and nearby physician and emergency medical care.

2.5.4. Training and education

The purpose of the corporation's training and education efforts are to ensure that employees are sufficiently informed about ergonomics principles and injury prevention to actively participate in the corporation's ergonomics efforts. In addition, the training incorporates topics about how employees can participate in the program. The training audience includes all hourly employees (plant and office), engineering and maintenance personnel, supervision, management, and health care providers in all plants. The training is presented in applicable language at an appropriate level of understanding for the target audience. Topics include proper and safe work methods; the physiology and symptoms of cumulative trauma disorders; and means of prevention, coping, or treatment.

2.6. Implementation

All components of the corporation's Ergonomics Program were implemented simultaneously in 1986. Since the Ergonomics Program has been operating for several years, a certain methodological pattern has emerged in terms of implementation. In general, the Corporate Ergonomics Coordinator first examines the injury investigation reports for a plant or a specific department within a plant. These reports are used to target specific jobs for evaluation. The next step is a Safety and Ergonomics Survey. This survey, completed by all workers performing all jobs in the plant, asks about the presence of symptoms (lasting aches or sore spots); the perceived cause of these symptoms; the comfort

of the workstation; the comfort of tools (if any); miscellaneous questions related to the way the job is performed (e.g. lifting, lighting, pushing, pulling, posture, footing, noise, reach envelope); and other safety-related issues. The responses for each Safety and Ergonomics Survey are reviewed by the industrial engineer assigned to the department. Obvious hazards are addressed immediately. Other identified or suggested problems, such as the presence of musculoskeletal risk factors, are marked for special study. The results of the survey and any corrective actions are communicated to the Corporate Ergonomics Coordinator.

The next step is to prepare supervisors and workers at the plant for upcoming study of the ergonomics-related problems identified in the survey. These activities are done by ergonomics teams composed of representatives from production workers, clerical workers, management, supervision, mechanics, and engineers. In general, the production and clerical workers are volunteers that, if represented by a union, would either be selected or endorsed by the union. The committees are structured so that the number of worker and management representatives are balanced. All members of the ergonomics teams are trained by the Corporate Ergonomics Coordinator. This training includes information related to musculoskeletal risk factors, musculoskeletal disorders, and teamwork. As of 1993, this training had been given to over 5000 plant employees participating on ergonomics teams.

Each ergonomics team studies each job in its department using assessment tools developed by the corporation – i.e. a Cumulative Trauma Disorder (CTD) Risk Factor Checklist and a Job Analysis Checklist. The CTD Risk Factor Checklist inquires about the presence of generic risk factors for upper extremity disorders as well as postural stability, unaccustomed activity, work pace, and selected personal characteristics. The Job Analysis Checklist is a one-page checklist that asks about risk factors related to the torso, the hands, the wrists, and the environment in general. This checklist is also being developed so that it can be matched to a worker capability assessment, completed by health care providers, to optimize matching of worker capabilities to job demands, especially for workers returning after injury with limited capabilities.

In addition to the assimilation of data from the Safety and Ergonomics Survey, the CTD Risk Factor Checklist, and the Job Analysis Checklist, the ergonomics teams also meet with the workers performing the jobs. One or more team members, using a Worker Feedback Form as a guide, meet with workers individually to discuss the job (perceived problems and recommended solutions) and its effects on that worker (body part discomfort). Following this data collection process, the ergonomic teams summarize their findings, brainstorm possible solutions (e.g. new ideas, new opportunities to apply old ideas or interventions from other facilities), and discuss potential problems associated with the proposed solutions. After the teams reach consensus on the recommended interventions, implementation is discussed with supervision and their findings are documented in writing.

Prior to submitting a recommendation for change to management, the ergonomics teams use a checklist for ergonomic safety and efficiency as an additional level of assessment of the intervention. This checklist is presented to the plant manager and, when approved, referred to the Corporate Engineering Group for consideration. The Corporate Engineering Group reviews the ergonomics team's findings, obtains clarification of any obscure or confusing findings, and prioritizes the recommended interventions. The team leader of each ergonomics committee, usually an industrial engineer, works with the Corporate Engineering Group to sort, assign, and schedule follow-up evaluation. As needed, the teams or the Corporate Engineering Group obtains assistance related to design, drafting, ordering, and/or installing new equipment. They may also need assistance in obtaining appropriate approvals (e.g. from the United States Department of Agriculture) and obtaining appropriated funds. All negative comments related to this checklist must be addressed before the plans for intervention are considered acceptable.

When necessary, an ergonomics team can use a task force approach that incorporates a larger scope of human resources at the plant. The ergonomics teams also revisit prior interventions to follow-up on their effectiveness and review new or

proposed workstations or operations. The teams also assess or monitor all new installations or modifications at the plant to ensure 'ergonomic correctness'. This may involve administration of one or more of the checklists. Finally, the teams provide information and success stories to corporate for distribution to other plants.

2.7. Communication

Each ergonomics team submits a monthly status report. This report is organized as a standardized agenda to be used for an ergonomics team's monthly meeting. At the corporate level, these monthly reports (from all ergonomics teams in all plants within the corporation) are reviewed by the Industrial Engineering Manager and the Corporate Ergonomics Coordinator. This allows them to monitor each plant's or team's activity and progress. Since 1988, corporate has published a quarterly newsletter entitled 'What's New in Ergonomics'. The purpose of this newsletter is to communicate news related to ergonomics, report on the status of the ergonomics program, serve as a reminder so that heightened awareness is maintained, and share the experiences of individual ergonomics teams.

2.8. Examples of ergonomic interventions

Prior to 1982, deboning picnics required over 25 workers using knives to manually dissect out the bone from the picnic. Aside from the inevitable cuts and bruises, this work was associated with a large number of upper extremity disorders. In 1980, the corporation started a project to examine the possibility of automating this difficult task. A corporate Methods and Layout Engineer worked with a Dutch food equipment manufacturer to adapt their machinery to their production process. The design was based on squeezing the meat from the bone. Four Deboning Machines were introduced at one plant in 1983. The new process involved four machines and five workers (two operators, two meat inspectors, and a trucker). This equipment was subsequently installed in two other plants. The same principle was later adapted to the deboning of hams. These machines were installed at four plants. This change improved the quality of meat for the corporation's products. Yield increased slightly, but this slight increase, when multiplied by millions of hogs per year, was significant.

The company has also invented several devices, such as automatic hog splitters and hand-held skinners and markers. These inventions have been licensed for manufacturing and sale by national distributors.

Several devices available from national distributors have been modified for unique applications at the company. Examples include the development of new handles for vacuum carrying devices for manipulating heavy boxes, barrels, or bags, and modifications to Whizard knives (new handles).

The company has also developed a variety of innovations for their own use. These include: bacon comb lifters; casing and film roll manipulators; bacon comb sharpeners and straighteners; and belly inverters. Projects nearing installation include automated pulling of loins and automatic trimming of bellies.

3. Methods

3.1. Program evaluation criteria

Information related to injuries and illnesses were derived from the corporate OSHA 200 logs. The OSHA 200 logs are records that are required to be maintained by the US Department of Labor (OSHA, 1986). According to the recordkeeping requirements, all work-related occupational injuries and illnesses (except extremely minor ones treated only with first aid) that occur during a calendar year are required to be recorded on that year's OSHA 200 log. The OSHA 200 logs are required to be maintained for 5 yr. At this corporation, each OSHA 200 entry included a case number; the date of injury or illness; the employee's name; an abbreviated description of the condition; and the employee's department and occupation; and if the injury or illness did or did not involve lost or restricted work days and, if so, the number of days away from work or the number of days on restricted activity. For illnesses only, it was also noted if the illness was a skin disorder; a dust

disease of the lung; a respiratory condition caused by a toxic agent; systemic poisoning; a disorder due to repeated trauma or physical agents; or another type of occupational illness. Workers' compensation cost data was obtained from annual reports sent to the corporation by their workers' compensation insurance carrier.

Crude annual incidence rates were calculated by dividing the total number of injuries and illnesses recorded on the OSHA 200 log for each year by the average number of workers employed by the corporation during that year, then multiplying by 100. Since OSHA 200 records were retained only 5 yr, crude annual incidence rate data were only available for years 1987–1993 (all post-implementation years).

Lost-time incidence rates were calculated in a manner similar to the crude incidence rates, except only the number of lost-time injuries was included in the numerator. Lost-time incidence rate data were available back to 1984.

The *percentage of recordable incidents related to musculoskeletal risk factors* was calculated by dividing the number of musculoskeletal disorders related to musculoskeletal risk factors by the total number of recordable incidents. Data was available for years 1987–1993.

The company preferred not to publish its crude incidence rates and lost-time incidence rates directly; therefore, results were presented in the form of a percentage relative to a baseline year. For the crude incidence rates, the rate for 1987 (the first year) was chosen as the baseline and assigned a value of 100%. Rates for years 1988–1993 were expressed as percentages of the 1987 rate. For the lost-time incidence rates, the rate for 1984 was used as the baseline.

Workers' compensation cost data were available for the years 1987–1993. Workers' compensation costs include expenses related to medical treatment and evaluation, wage replacement during periods of temporary disability (usually 67% of base), payments for permanent disability, and legal expenses. Given this scope of potential expenses, workers' compensation expenses often do not correlate with other measures of injury severity, e.g. the lost-time incidence rate. Benefits may vary state-to-state. In this project, *annual workers' compensation costs* were compared using constant dollars (adjusted for inflation). According to the corporation's top insurance executive, the company's average annual rate of inflation for this expense was 12% in this time period. As with the injury/illness statistics, the company preferred not to report its absolute dollar figures; therefore, 1987 was used as a baseline with costs from subsequent years reported as a percentage of this year.

Annual corporate workers' compensation expenses per employee (*per capita workers' compensation costs*) were calculated by dividing the annual workers' compensation costs for one year by the average number of workers employed during that year. As before, the results were expressed as a percentage of 1987. The per capita costs were *not* adjusted for inflation.

Evidence of trend was evaluated using the Cox–Stuart test for trend (Daniel, 1978). Since this method requires at least 10 observations to determine significance at the 0.05 level, it was not possible to determine a statistically significant trend for outcomes other than the lost-time incidence rate.

4. Results

4.1. Injury and illness statistics

In the baseline year (1987), the crude incidence rate for the corporation was approximately 2.5 times greater than the rate for US private industry and approximately 20% less than the rate for the US meat products industry. The crude incidence rates increased during the early post-implementation period, then reached a plateau at a level approximately 33% higher than baseline (Fig. 3). In the most recent two years, the crude incidence rate decreased and was almost equal to the 1987 level.

The corporate lost-time incidence rate in the baseline year (1984) was approximately 4 times higher than the rate for private industry and approximately 25% higher than the rate for the US meat products industry. The lost-time incidence rates, expressed as a percentage of the 1984 rate, exhibited a consistent and marked decrease in the

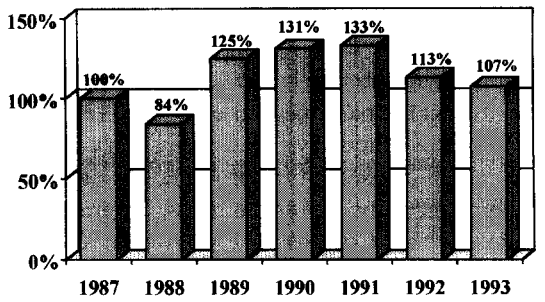

Fig. 3. Annual crude incidence rates for the years 1987–1993 expressed as a percentage of the 1987 rate. This rate represents the number of injuries and illnesses per 100 workers for the specified year. In the baseline year (1987), the incidence rate for the corporation was approximately 2.5 times greater than the rate for US private industry and approximately 20% less than the rate for the US meat products industry.

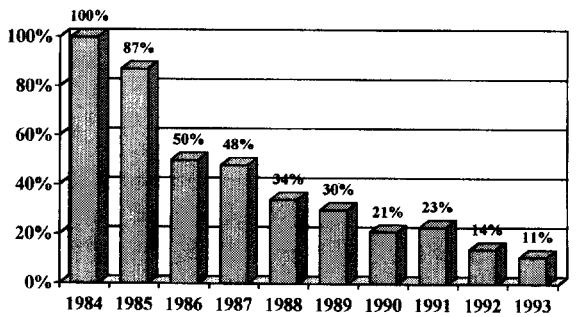

Fig. 4. Lost-time incidence rates for years 1984–1993 expressed as a percentage of the rate in 1984. The program was implemented in 1986. This rate represents the number of injuries and illnesses with at least one day of lost or restricted work per 100 workers for the specified year. In the baseline year (1987), the rate for the corporation was approximately 4 times higher than the rate for US private industry and approximately 25% higher than the rate for the US meat products industry. For years 1990–1993 (inclusive), the rates for the corporation were below the rates for private industry.

lost-time incidence rate since the implementation of the ergonomics program (Fig. 4). This downward trend was statistically significant ($p < 0.05$).

For years 1987 and 1988, approximately 67% of the recordable incidents on the OSHA 200 log were musculoskeletal disorders related to musculoskeletal risk factors (Fig. 5). For years 1989–1993, this percentage decreased by 37% to a mean value of 42% (range: 37–46%).

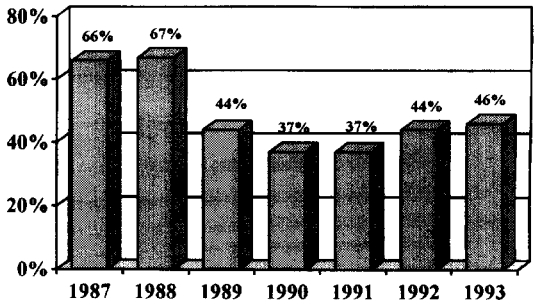

Fig. 5. Percentage of total recordable conditions that were musculoskeletal conditions (e.g. strains or sprains) related to musculoskeletal risk factors (e.g. lifting, lowering, or carrying) for the years 1987–1993.

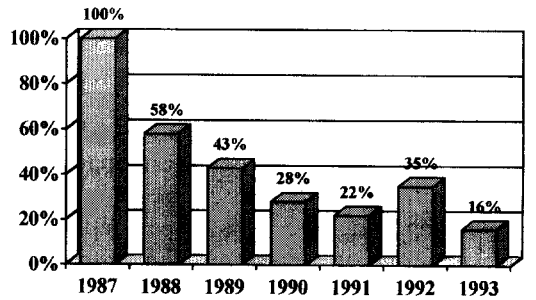

Fig. 6. Annual corporate workers' compensation expenses for years 1987–1993 expressed as a percentage of 1987 expenses (adjusted for inflation).

4.2. *Worker's compensation costs*

Annual workers' compensation costs, expressed as a percentage of 1987, decreased since 1987 (Fig. 6). While the decline was not particularly steady, there was an overall decrease in this expense subsequent to implementation of the ergonomics program. The 1993 expenses were 16% of those of 1987 (an 84% decrease). If inflation were disregarded, 1993 expenses were 31% of those of 1987 (a 69% decrease). According to company personnel, a decrease in workers' compensation expenses had not been observed prior to the start of the company's ergonomics program.

Per capita workers' compensation expenses progressively declined (Fig. 7). The 1993 expenses per employee was approximately 73% lower than in 1987.

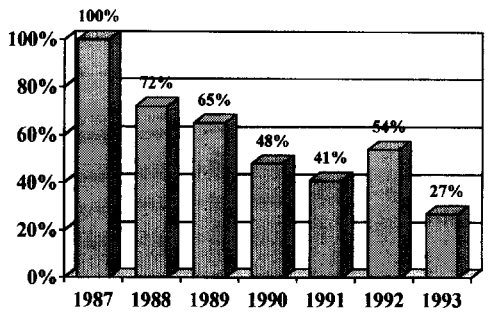

Fig. 7. Annual per capita workers' compensation expenses for years 1987–1993 expressed as a percentage of 1987 (not adjusted for inflation).

5. Discussion

One purpose of the demonstration project was to evaluate the effectiveness of an established ergonomics program that relied on a participatory approach to solving ergonomics problems in the red meat packing industry. This paper reports an evaluation of one such program. The observations are primarily descriptive. Since the methodology was not experimental, e.g. there were no control or comparison groups, it was not possible to draw definitive conclusions regarding factors that caused or contributed to the observations.

To describe the long-term effects potentially related to implementing a participatory ergonomics program, this analysis examined injury and illness statistics plus workers' compensation costs. Except for one measure, the lost-time incidence rate, it was not possible to compare pre-implementation data to post-implementation data because such data were not available. As a result, most of the observed changes reflect the corporation's experience in the years just after implementation of the program. Given the way the corporation implemented its program, it was not possible to apportion the observed changes among the various program elements. It is possible that factors other than the ergonomics program contributed to some of the observed changes.

The 1987 crude incidence rate for the corporation was several-fold greater than the rate for US private industry and modestly less than the rate for the US meat products industry. As a result, the observed changes were not likely due to this corporation having uniquely low or high crude incidence rates at the baseline year compared to the US meat products industry. The annual crude incidence rate increased by approximately one-third after implementing the ergonomics program. According to the Corporate Ergonomics Coordinator, employee training on early recognition and reporting of musculoskeletal conditions was believed to be a major contributing factor to this observation. It was a bit premature to be certain, but the data also suggested that the corporate crude incidence rate may ultimately decrease as the program matures (increases beyond a few years). Comparison of Figs. 1 and 3 suggests some similarity between trends in the US meat products industry and this corporation during years 1987–1993 (inclusive). One possible explanation is that reporting and recording of injuries and illnesses in the US meat products industry may have increased following the OSHA citations in 1987 and 1988, including the implementation of ergonomics programs as part of the 'settlement agreements' for the two largest US meat packers. Overall, these observations suggested that an increase in crude incidence rate might be expected following implementation of an ergonomics program and it might take several years for the incidence rate to fall back to its pre-implementation level. If effectiveness was to be measured by a crude incidence rate yardstick, institution of a participatory ergonomics program appeared to require a long-term perspective. In fact, an increased crude incidence rate may reflect an effective program.

There was a dramatic and statistically significant downward trend in the lost-time incidence rate. The corporation's 1987 lost-time incidence rate was several-fold above the rate for private industry and only slightly higher than the US meat products industry. As a result, the observed changes were not likely due to this corporation having uniquely low or high lost-time incidence rate at the baseline year. The lost-time incidence rate for the corporation dropped 50% during the first year of the ergonomics program (1986) to a level that was approximately half the rate for the US meat products

industry that year. This rate continued to fall annually thereafter; and, during years 1990–1993 inclusive, dropped below the rate for US private industry. The lost-time incidence rates in US private industry and the US meat products industry were essentially constant during this time period (see Fig. 2). Therefore, the changes in the corporate rates are unlikely to be explained by general factors, e.g. economic or labor conditions. In 1993, this rate was only 11% of that observed in 1984 – an 89% decrease. In general, this same phenomenon has been observed by others that used a participatory approach to ergonomics (Garg and Owen, 1992; McKenzie et al., 1985; Moore, 1994). There are several possible interpretations for this downward trend. The Corporate Ergonomics Coordinator attributed this observation to ergonomics and safety-related improvements as well as other factors, such as altered assignments for workers recovering from injuries. Since this decrease in lost-time incidence rate occurred while the crude incidence rate increased, it is also possible that the reported conditions were associated with less impairment or that workers were able to continue to perform their usual jobs, perhaps due to train- ing that emphasized early reporting, thus not accruing any lost or restricted days. There is suggestion of a downward trend prior to the implementation of the ergonomic program in 1986. While no single explanation can be reliably offered for this observation, it was noted that the corporation had implemented (and was implementing) several significant interventions prior to the implementation of the program (see Ergonomic Interventions).

Even though the crude incidence rate increased 33% in the post-implementation years, the percentage of recordable disorders related to musculoskeletal risk factors decreased 37% during this same period. These changes are approximately equivalent to an overall 20% decrease in the number of recordable disorders related to musculoskeletal risk factors. According to the Corporate Ergonomics Coordinator, the percentage decrease in recordable disorders related to musculoskeletal risk factors varied from plant to plant. Highly automated facilities, e.g. canning plants, observed decreases ranging from 9 to 16%. Less automated facilities with hand-intensive processes, e.g. meat processing and packaging plants, observed decreases ranging from 50 to 66%.

Even though there was insufficient number of years to demonstrate a statistically significant downward trend for workers' compensation costs, the corporation experienced financially meaningful decreases for annual as well as per capita expenditures. Based on inflation-adjusted dollars, the annual workers' compensation costs decreased 84% over 6 yr. This represented several millions of dollars in savings. Unadjusted per capita costs decreased 73%. These savings in workers' compensation costs would have a major impact on any company's profitability, but was especially significant in the red meat packing industry. Corporate personnel estimated that a $1000 expense required the sale of approximately 35 000 pounds of product in order for the profits from this sale to cover this expense.

6. Conclusions

The observations associated with this project were consistent with the inference that the long-term effects of a structured, centrally managed, participatory ergonomics program were favorable for one corporation. The following were noted during the years following implementation of such a program:

1. an increase in the crude incidence rate (at least for several years),
2. a marked decrease in the lost-time incidence rate,
3. a significant reduction in the percentage of musculoskeletal disorders related to musculoskeletal risk factors,
4. a marked reduction in total and per capita annual workers' compensation costs.

While not known with certainty, it is possible that these results might also be observed in other industries or work environments that implement a participatory ergonomics program.

Acknowledgements

This study would not have been possible without the patience, assistance, and support of the

employees of the corporation and its plant. This includes all members of the ergonomics teams and especially the Corporate Ergonomics Coordinator. This work was supported by NIOSH Cooperative Agreement No. U60/CCU508741-01. The investigators wish to thank the study sponsor for its financial and administrative support for this project and David Holliday, Ph.D., Associate Professor in the Department of Epidemiology and Biomathematics at the University of Texas Health Center at Tyler, for assistance with the statistical analysis.

References

Bureau of Labor Statistics, 1996. Occupational Injury and Illness Rates. Internet address: http://stats.bls.gov/cgi-bin/dsrv.

Daniel, W.W., 1978. Applied Nonparametric Statistics. Houghton Mifflin, Boston, pp. 58–62.

Falck, B., Aarnio, P., 1983. Left-sided carpal tunnel syndrome in butchers. Scandinavion Journal of Work Environment and Health 9, 291–297.

Garg, A., Owen, B., 1992. Reducing back stress to nursing personnel: an ergonomic intervention in a nursing home. Ergonomics 35, 1353–1375.

Habes, D.J., 1994. Introduction. In: Gjessing, C.G., Schoenborn, T.F., Cohen, A. (Eds.), Participatory Ergonomic Interventions in Meatpacking Plants. DHHS (NIOSH) Publication No. 94-124, pp. 5–8.

Kurppa, K. et al., 1991. Incidence of tenosynovitis or peritendinitis and epicondylitis in a meat-processing factory. Scandinavian Journal of Work Environment and Health 17, 32–37.

Masear, V.R., Hayes, J.M., Hyde, A.G., 1986. An industrial cause of carpal tunnel syndrome. Journal of Hand Surgery 11A, 22–227.

McKenzie, F., Storment, J., Van Hook, P., Armstrong, T.J., 1985. A program for control of repetitive trauma disorders associated with hand tool operations in a telecommunications manufacturing facility. American Industrial Hygiene Association Journal 46, 674–678.

Moore, J.S., 1994. Flywheel truing: A case study of an ergonomics intervention. American Industrial Hygiene Association Journal 55, 236–244.

Moore, J.S., Garg, A., 1994a. Case Study #2. In: Gjessing, C.G., Schoenborn, T.F., Cohen, A. (Eds.), Participatory Ergonomic Interventions in Meatpacking Plants. DHHS (NIOSH) Publication No. 94-124, pp. 93–161.

Moore, J.S., Garg, A., 1994b. Upper extremity disorders at a pork processing plant: Relationships between job risk factors and morbidity. American Industrial Hygiene Association Journal 55, 703–715.

Moore, J.S., Garg, A., 1996. Uses of participatory ergonomics teams to address musculoskeletal hazards in the red meat packing industry. American Journal of Industrial Medicine 29, 402–408.

Moore, J.S., Garg, A., in press. Participatory Ergonomics in a Red Meat Packing Plant, Part 1: evidence of Effectiveness. American Industrial Hygiene Association.

Moore, J.S., Garg, A., in press. Participatory Ergonomics in a Red Meat Packing Plant, Part 2: Case Studies. American Industrial Hygiene Association.

National Institute for Occupational Safety and Health, April 1989. John Morrel, Sioux Falls, SD, HETA 88-180-1958.

Occupational Safety and Health Administration, 1986. A Brief Guide to Recordkeeping Requirements for Occupational Injuries and Illnesses. OMB No. 1220-0029.

Occupational Safety and Health Administration, 1990. Ergonomics Program Management Guidelines for Meatpacking Plants. OSHA No. 3123.

Sheridan, P.J., May 1991. Meatpackers move to cut injury rates. Occupational Hazards, 81–85.

Viikari-Juntura, E., 1983. Neck and upper limb disorders among slaughterhouse workers. Scandinavion Journal of Work Environment and Health 9, 283–290.

Viikari-Juntura, E. et al., 1991. Prevalence of epicondylitis and elbow pain in the meat-processing industry. Scandinavian Journal of Work Environment and Health 17, 38–45.