

Implementation of an ergonomics process at a US surface coal mine

Janet Torma-Krajewski^{a,*}, Lisa Steiner^a, Pauline Lewis^a, Paul Gust^b, Kean Johnson^b

^aNational Institute for Occupational Safety and Health, Pittsburgh Research Laboratory, 626 Cochran Mill Road, Pittsburgh, PA 15236, USA

^bBridger Coal Company, Point of Rocks, WY 82942, USA

Available online 26 December 2006

Abstract

Since 1990 and the publication of the *Ergonomics Program Management Guidelines for Meatpacking Plants* by the US Occupational Safety and Health Administration, numerous reports of companies implementing ergonomics program have been published. However, despite these numerous reports, no examples of implementing an ergonomics program in the mining industry have been reported. In 2000, NIOSH initiated a long-term project to demonstrate the implementation of an ergonomics process designed to identify and reduce exposures to ergonomic risk factors found in mining. The mine selected for this project was the Jim Bridger Mine, a surface coal mine located 35 miles northeast of Rock Springs, Sweetwater County, WY. This paper discusses how a large, surface coal mine implemented an ergonomics program and the lessons learned while doing so.

Relevance to industry

In 1998, the Mine Safety and Health Administration (MSHA) submitted a formal request to NIOSH to investigate musculoskeletal disorders (MSDs) in the mining industry. In response to MSHA's request, NIOSH initiated a project at the Jim Bridger Mine that involved the implementation of an ergonomics process. This manuscript provides examples of successful interventions as well as recommendations and lessons learned from the implementation of an ergonomics process that will be beneficial to those initiating similar efforts.

© 2006 Elsevier B.V. All rights reserved.

Keywords: Ergonomics program; Ergonomics process; Mining

1. Introduction

Prior to 1980, the industrial application of ergonomics in the United States largely focused on defining physical capabilities of workers and physiological responses to various working conditions. Companies supporting these early ergonomic efforts, mainly through applied industrial research activities, included E.I. duPont de Nemours & Company and Eastman Kodak Company (Eastman Kodak Company, 1983). Early research efforts specific to the US mining industry were focused on describing physiological characteristics of miners (muscular strength and aerobic capacity), evaluating physiological responses when performing mining tasks, analyzing injury data and evaluating manual material handling tasks. Many of these

studies were conducted for the Bureau of Mines, United States Department of the Interior (Bureau of Mines, 1981, 1983, 1987).

Not until the United States Department of Labor, Occupational Safety and Health Administration (OSHA) initiated enforcement actions directed at the meat packing industry in the 1980s, did companies located in the United States begin to consider the implementation of formal ergonomics programs or processes as a means of proactively improving worker safety and health through the prevention of musculoskeletal disorders (MSDs). For the purposes of this paper, an ergonomics process is defined as a formal, systematic application of ergonomics principles integrated with management systems and imbedded in the organizational culture. Such a process would be comparable to an occupational safety and health program designed to address health and safety hazards through a systematic method of hazard recognition, identification,

*Corresponding author. Tel.: +1 303 423 2069.

E-mail address: jht8@cdc.gov (J. Torma-Krajewski).

evaluation and control. Although ergonomic interventions implemented outside of a systematic process may initially lead to job improvements, ongoing improvements may not occur when an infrastructure has not been built to sustain the continuing application of the interventions, as well as initiating new interventions. According to Straker (1990), ergonomic interventions developed by participatory work teams may result in significant impact, but the efforts of the work teams may not continue unless the work teams are part of a process integrated with management systems and supported with written policies, procedures and responsibilities.

OSHA (1990) published the *Ergonomics Program Management Guidelines for Meatpacking Plants*, which defined basic elements of formal ergonomics programs, and served as a template for the meatpacking industry, as well as general industry. Programs implemented in the meatpacking industry were described by Gjessing et al. (1994) and by Moore and Garg (1998). Since then, several case studies of ergonomics programs in other industries located in the United States and other countries have been published. Industries identified in these reports included the beverage, cosmetic, telecommunications, electronics, financial planning, automotive, light manufacturing (abrasive products and shoes), health care, utilities and food industries, as well as office environments (Gauf, 1995; US Government Accounting Office, 1997; Perry, 1997; Hignett, 2001; Hägg, 2003; Munck-Ulfsfält et al., 2003; Butler, 2003; Smyth, 2003; Joseph, 2003; Moreau, 2003). These case studies generally demonstrated effectiveness with pre- and post-implementation data, such as reductions in injury rates, compensation costs, work days lost, etc. Following a randomized controlled study design, Straker et al. (2004) reported the efficacy of implementing the PerforM (Participative Ergonomics for Manual Tasks) intervention in three different Australian industries (food processing, construction-related manufacturing and health/community services). This intervention established participatory work teams trained in risk management of manual tasks. Although the intervention was found to be effective in reducing the overall workplace risk, the evaluation period was relatively short-term, approximately 3 months. The long-term success of this intervention has not been reported.

Despite the numerous reports of ergonomics programs in a variety of industries, no examples of implementing an ergonomics program in the mining industry have been reported. Mining environments pose challenges to implementing ergonomics processes and demonstrating effectiveness not found in other industries. Unlike manufacturing facilities, mining environments are constantly changing and can be considered very dynamic work environments (Steiner et al., 1999; Scharf et al., 2001). Additionally, working conditions often include harsh environmental conditions, such as restricted work spaces, hot and cold environments with muddy, wet, or icy floor/ground conditions, high levels of whole-body and segmental vibration, significant amounts

of manual work, and extended shifts up to 12 h/day. The number of miners performing a specific task is usually very limited; this impacts the number of miners affected by interventions and increases the difficulty of demonstrating the effectiveness of task-specific interventions. Schutte (2005) reported on a project by the South African Institute of Mining and Metallurgy to foster the integration of ergonomics with existing risk management systems. This project, which was initiated in 1999 with the development of a comprehensive strategy to facilitate the integration of ergonomics into the South African mining industry, will include developing a model ergonomics program and then piloting that program at several mines. The objective of this paper is to demonstrate that an ergonomics process can be effectively implemented in an industry with dynamic work conditions and environments and to present lessons learned throughout the implementation process.

2. Methods

2.1. Background

In 2000, NIOSH initiated a long-term project to demonstrate the effectiveness of implementing a process designed to identify and reduce exposure to ergonomic risk factors found in mining. The mine selected for this project was the Jim Bridger Mine, a surface coal mine located 35 miles northeast of Rock Springs, Sweetwater County, WY. This mine had one active pit approximately 20 miles in length, and an average production rate of 6.4 million tons of coal per year from 1995 through 2000. During the time frame of this project, the Jim Bridger Mine was operated by Pacific Minerals, doing business as the Bridger Coal Company, a PacifiCorp Company and subsidiary of Scottish Power.

The mine employed a work force of approximately 360 employees, 150 in coal production, 150 in maintenance and another 60 in administrative and support functions. Production staff worked two 12-h shifts, 7 days per week, while non-production staff worked either 10-h shifts, 4 days per week, or 8-h shifts, five days per week. The workforce was very stable, with very low attrition rates during the first three years of this project. From 2001 through 2003, the number of employees ranged from 350 to 381.

The workforce at this mine was composed mostly of workers who were 40 years or older. Fifty-nine percent of the workers were from 40 to 49 years, while only 20 percent were less than 40 years old. However, 36 percent of the workforce had less than 5 years of experience at their current job. This could indicate a period of hiring new employees within 5 years of initiating the ergonomics process. In fact, the number of employees did increase from 382 in 1995 to 401 in 1997. However, this increase in employment represented only a 5 percent change, and could not explain the percentage of the workforce with less than five years of experience with their current job.

Another probable explanation could be that existing employees were changing jobs. This could have ergonomic implications if older employees sought jobs with exposures to ergonomic risk factors. For example, the highest paying production position at this mine was dragline operator. This position involved exposure to repetitive motion while operating joysticks or foot pedals for 12 h/day. Several studies have found age to be associated with a higher rate of MSDs (Biering-Sørensen, 1983; Riihimäki et al., 1989; Toomingas et al., 1991; Ohlsson et al., 1994; English et al., 1995; Guo et al., 1995). Additionally, in one study, older workers with less work experience reported more symptoms than younger workers, while older workers with more work experience reported fewer symptoms than younger workers (Ohlsson et al., 1989).

For five years prior to this project, the average incident rate for non-fatal days lost injuries at the Jim Bridger Mine was 1.32 injuries per 100 employees, as compared to the national average of 2.34 for all mines, and as compared to the average of 1.31 for all western US surface coal mines with more than 100 employees. Although, the Mine's average incident rate was well below the national average and injuries related to ergonomic risk factors did not appear to be a major issue, the Bridger Coal Company decided to implement an ergonomics process. This action was consistent with Mine Management's proactive approach to safety and health and its culture of seeking continuous improvement. Information on why the Bridger Coal Company decided to implement an ergonomics process can be found in Steiner et al. (2004).

2.2. Process effectiveness

To assess the effectiveness of the process, two approaches were followed. First, reports of employee discomfort were obtained using a discomfort survey adapted from the Standardized Nordic Questionnaire (Kurionka et al., 1987). The survey was administered in 2001 by NIOSH researchers and again in 2004 by Bridger Coal Company management. Although 225 employees completed the survey in 2001 and 116 completed it in 2004, only 41 surveys could be matched for both years. The lower response rate in 2004 was attributed to a significant change in personnel (both turnover and reassignments) when the mine began converting its operations from surface to underground. Because of the limited number of matched pairs, statistical analyses were not performed and only trends are reported.

Secondly, employee reports of risk factor exposures and intervention efforts were documented and tracked by the Ergonomics Committee. The risk factor exposure data were obtained from employees who submitted concerns to the committee.

2.3. Getting management buy-in

It was essential to have the support of Bridger Coal's top management for the ergonomics process to be successful at

the Jim Bridger Mine. The key to a successful implementation is a senior management with a strong understanding and support of the programmatic concepts and elements (Cohen et al., 1997). Two meetings were held to introduce this project to top management of the Bridger Coal Company and PacifiCorp and also to the Western Energy Workers Union, the union representing Bridger Coal Company employees.

The initial meeting, attended by mine management and union officials, was held in Rock Springs, WY to discuss the objectives of the project and to define expectations and commitments. One expectation discussed was that the Bridger Coal Company needed to designate a "champion" for the project who would promote the implementation of the process and ensure that the process moved forward. Information on ergonomic principles, risk factors and approaches used by other companies in successfully addressing ergonomic risk factors was also provided. The second meeting, held in Salt Lake City, UT, was with senior safety administrators from within PacifiCorp's Generation Business Unit. NIOSH again presented approaches used by other companies and then defined the benefits of implementing an ergonomics process. Providing information on how ergonomics benefited these other companies was absolutely necessary to get complete buy-in and support from these senior management officials. These meetings resulted in corporate awareness of the ergonomics process to be implemented at the Jim Bridger Mine, and also additional champions for ergonomics.

2.4. Ergonomics committee

Bridger Coal's management decided that the best approach to implementing an ergonomics process was to establish an ergonomics committee within the Safety Department, but separate from the existing safety and health committee. This approach allowed Bridger to more easily commit resources specific to ergonomic interventions. The committee, chaired by an ergonomics coordinator who reported to the safety manager, included eleven representatives from labor and management. Specific departments represented were medical, engineering/environmental, safety, human resources, production and maintenance. Mine management was kept informed of committee activities and needs through the ergonomics coordinator and safety manager who reported to the mine manager. The union was kept abreast of committee actions by the union representatives appointed to the committee.

One of the first actions taken to move the committee forward was to help the committee gain an understanding of ergonomics. The Committee received training at the mine on the principles of ergonomics, risk factor identification, job prioritization, intervention recommendations, and cost/benefit analysis. During follow-up training sessions, the Committee received instructions on using tools to document interventions, task analyses, and interviews; conducting interviews; videotaping/photographing tasks;

and prioritizing interventions. This training was a combination of classroom instruction and field exercises so members could gain experience at conducting task analyses and identifying risk factors.

NIOSH researchers and members of the Ergonomics Committee participated in a brainstorming session to develop a plan that would determine how the committee would proceed. This plan addressed responsibilities, meeting format, communications, reporting format and meeting times. One of the first tasks tackled by the committee in developing its plan was to define a mission statement (identify, evaluate and correct working conditions that need ergonomic improvement) and an overall goal (to create a healthier workplace through employee involvement).

2.5. Ergonomics process

Because the Bridger Coal Company decided to implement its ergonomics program separate from its safety and health program, it was necessary for the Ergonomics Committee to define a procedure for processing concerns. The Committee used two documents for employees to present concerns to them for follow-up, an “Employee Ergonomic Concern” form and a “Risk Factor Report Card.” Both were designed to be completed by employees and are shown in Fig. 1. The Ergonomic Concern form requested specific information about equipment and work area, the nature of the concern and whether the concern was acute or cumulative in nature. The Report Card was a 4 × 6-inch card, which gave employees a mechanism to also identify potential risk factors and affected body parts, and note any comments and/or suggestions. Employees could complete either document, or both, which was encouraged by the Committee.

The steps followed by the Ergonomics Committee for processing a concern are shown in Fig. 2. The concern was screened by the committee chairperson to determine if the

problem involved exposure to ergonomic risk factors and if the exposure could be easily controlled without involvement of the Committee. If the exposure could not be resolved immediately, the concern was discussed at the next meeting, and then was assigned to a committee member for further review, which would include discussions with the employee submitting the concern. Subcommittees investigating concerns usually involved employees directly affected by the concern.

2.6. Employee training

Once the Ergonomics Committee was trained and had developed the procedure for processing concerns, employees were given training that focused on recognizing ergonomic risk factors and taking action by reporting risk factors to the Ergonomics Committee. Employees were told to be proactive and to target risk factors and not wait until an injury occurred. The employees were given information on how a cumulative trauma disorder may develop, and how it is better to take action by eliminating risk factors before a disorder occurs. Employees were taught how to report a concern using the Risk Factor Report Card. The primary training module was geared to employees in production and maintenance. A second version of the training focused on office ergonomics and was given to administrative support employees.

This 90-min training was presented by NIOSH personnel and committee members, who introduced the training and then ended the training by encouraging employees to be involved in this process. Approximately 280 employees were trained during 21 sessions. Because of the different shifts worked by the employees, the sessions were held over a 7-day period and were generally scheduled either at the end or at the beginning of the shift. To encourage participation in the training, NIOSH designed a sticker for workers attending the training. Since the miners placed the stickers on their hard hats and lunch containers, the

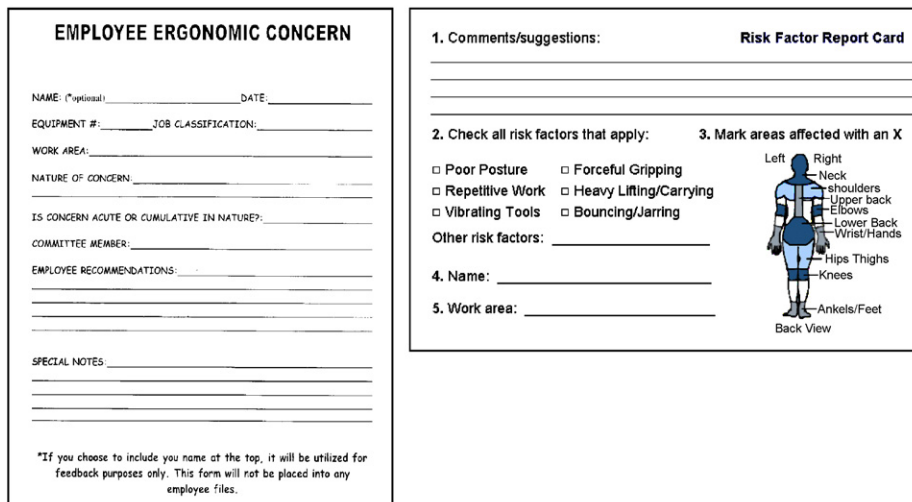


Fig. 1. Employee ergonomic concern form and the risk factor report card.

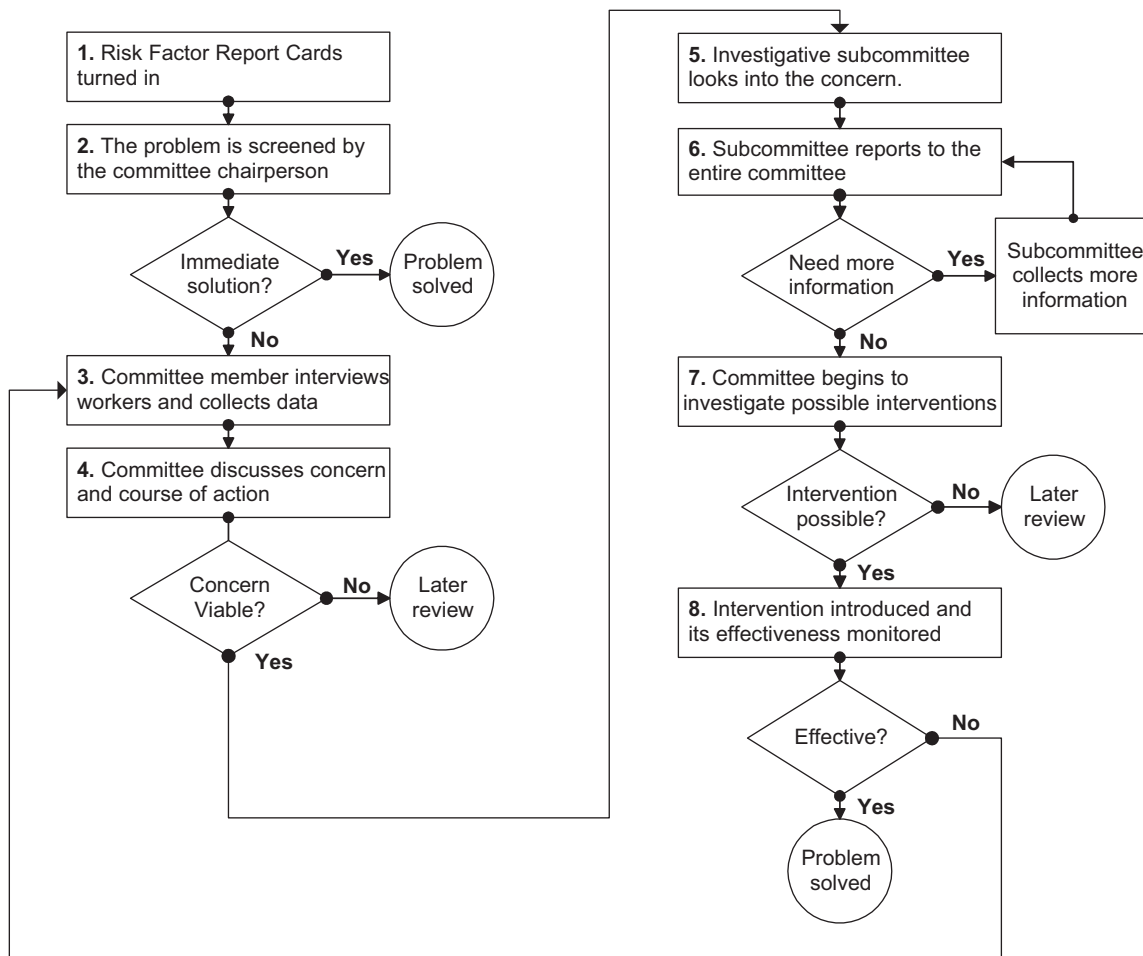


Fig. 2. Ergonomics process flow diagram. (Concerns considered not viable included ones that did not currently have a practical solution or the solution was beyond the scope of the committee.)

stickers also provided a continuing reminder to employees about the importance of ergonomics.

For the most part, the training was well received by the employees. Employees participated in the interactive exercises, and seemed quite knowledgeable regarding identifying risk factors at the conclusion of the training. In fact, 27 employees submitted report cards to the Ergonomic Committee immediately following the training. The effectiveness of the training was further demonstrated with the implementation of an intervention in a surface drill. According to the documentation for this intervention, the drill operator had tried several times to have a foot pedal moved to a more comfortable position but was not successful. However, the general knowledge gained from the training by both employees and management allowed them to understand how the problem with the foot pedal could be resolved, which was then corrected by the Maintenance Department.

2.7. Communications and recognition

The Ergonomics Committee established a bulletin board in the ready room, an area that all employees passed

through when reporting to work. The bulletin board included information about the committee, instructions for reporting a concern, and a status report of concerns submitted by employees. Posters were periodically displayed on this bulletin board and at other meeting areas at the mine. The posters focused on introducing the ergonomics committee to the employees, reporting risk factor exposures, promoting ergonomic interventions completed by the committee, and identifying risk factors for specific tasks.

PacifiCorp's quarterly safety newsletter, *Safety Times*, twice featured the success of Bridger Coal's ergonomics process. This newsletter was made available to all Bridger Coal employees, and served as recognition to not only the committee members for their efforts, but also to the employees submitting concerns for actively participating in the process.

2.8. Medical management

The Bridger Coal Company maintained a medical clinic at the Jim Bridger Mine that was staffed by a full-time physician assistant (who was also a physical therapist) and

a registered nurse. The clinic was opened during the day shift, four days a week, and during the night shift, one day a week. Services provided to the miners included medical care for both job-related and personal health issues. The physician assistant was a member of the Ergonomics Committee, and consequently the clinic took an aggressive approach to recognizing and addressing MSDs. Medical management of MSDs was considered a high priority for getting employees back to work.

2.9. Recordkeeping

A simple recordkeeping system was used for the ergonomics process. A listing of concerns was maintained as a Microsoft Excel spreadsheet that included all the information provided on the Risk Factor Report Card. Additionally, each concern was color coded to document the status of the concern. Concerns were labeled as either completed, in progress, items referred elsewhere or dismissed, or items on hold. The committee also maintained a Status/Update document that allowed employees to monitor the status of their concerns. This document, posted on the ergonomics bulletin board, provided a short description of the concern and the current status of the intervention. If a concern was referred elsewhere or dismissed, the basis for this decision was provided.

3. Results

3.1. Interventions

Three years into this process the Ergonomics Committee received a total of 55 concerns, and successfully completed improvements for 22 concerns. Five more concerns were actively being addressed, and nine other concerns were on hold pending the receipt of additional information. The remaining 19 concerns were either addressed as safety and health concerns or were not considered valid concerns.

The results of an analysis of the valid concerns are shown in Fig. 3. Of the 36 concerns processed by the Ergonomics Committee, one-third of the concerns were submitted by mechanics and another third by heavy equipment operators. The most frequently reported risk factor exposure was repetition, followed by heavy lifting and forceful gripping. The least reported exposure was vibration from using hand tools. Discomfort was most frequently reported in the lower back and wrists/hands.

Table 1 provides information on interventions implemented by the Bridger Coal Company, including those initiated by the Ergonomics Committee. Over half of the interventions involved the purchase of new equipment or new seats. However, all of the purchases except one were less than \$3000 (US). Some of the modifications were completed by the equipment maintenance staff, and did not result in significant expenditures of funds or time. The easiest type of concerns addressed by the Committee involved rearranging equipment or work areas. Although

many of the interventions appeared to be rather simple solutions, determining appropriate interventions usually involved detailed investigations and analyses to ensure employee acceptability and reduction in risk factor exposures. Activities performed when identifying and evaluating potential interventions often included employee interviews, risk factor determinations, product identification and evaluation, and manufacturer approvals. Only one complaint could not be addressed by the Committee because the intervention cost was considered prohibitive.

3.2. Discomfort survey

Reports of discomfort declined by 17 percent following implementation of the ergonomics process. Fewer employees reported discomfort for the head, elbows, wrists/hands, upper back and lower back (Fig. 4). The most frequently reported body part with discomfort was the lower back both before and after the process implementation. Also, before the process was implemented more employees tended to experience discomfort in multiple body parts. For example, before the process was implemented 24 percent of the employees reported discomfort in three different body parts, while after the process was implemented only 17 percent reported such discomfort (Table 2).

When considering the age of the employees and discomfort reports, the percentage of employees reporting discomfort prior to the process was greater for three age groups (31–40, 41–50 and over 50) when compared to the percentage of reports for the same age groups following the implementation of the process. A slightly downward trend in reporting discomfort (83–72 percent) with increasing age (31–40 years old to over 50 years old) was observed after the process was implemented. A decrease in discomfort with increasing age was not observed before the process was implemented. The same results were observed when considering discomfort reports for the lower back. Refer to Table 3.

3.3. Ergonomics process

In March 2004, several members of the Ergonomics Committee were interviewed by NIOSH to determine if they thought their process was effective. Overall, the members strongly believed the process was effective and did not believe any changes were needed. When problems with resolving concerns were encountered, they were generally related to external factors not associated with the process. For example, equipment manufacturers could not easily develop a retrofit, or suggested modifications could possibly void the equipment warranty. The importance of the ergonomics process was noted in the documentation for one of the interventions: “It is unclear if this item would have been completed in a timely manner or at all without the ergonomics program being in place and being well understood.”

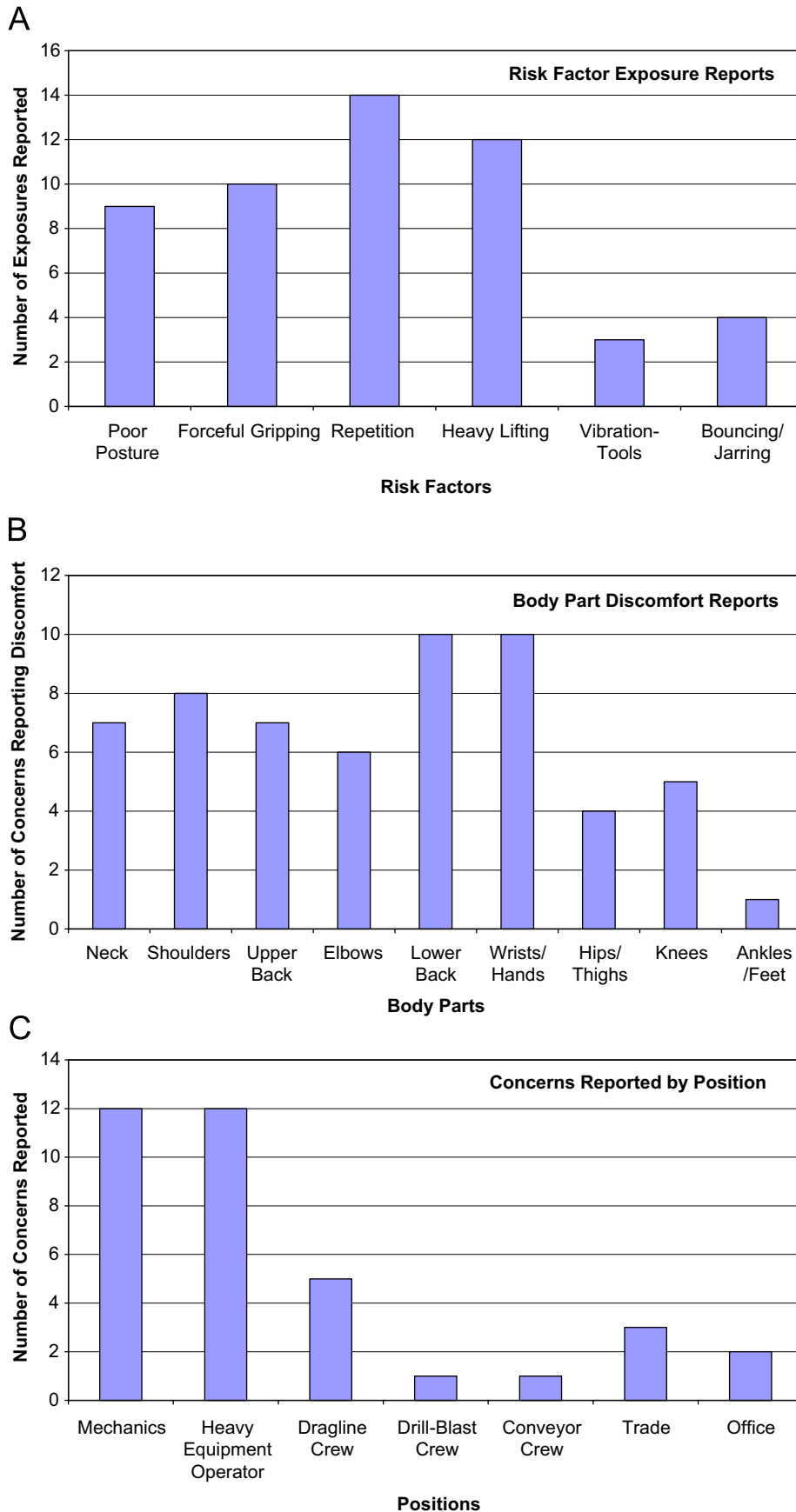


Fig. 3. Information submitted by employees using the Risk Factor Report Card (A—risk factor exposure reports, B—body part discomfort reports, and C—concerns reported by position).

Table 1
Description and type of interventions completed

Type of intervention	Number of concerns received	Brief description of intervention
Existing equipment modified	4	Handle added to chocks (19) ^a Loader foot pedal angle modified (5) Drill pedal moved to a more accessible location (11) Drill truck ladder handrail modified (11)
Workstation rearranged	5	Pump switch location changed (27) Loader seat aligned with controls (5)
New workstations purchased	2	Adjustable office workstations purchased (2)
New equipment purchased	9	Light weight welding helmets replaced heavier helmets (14) Wooden hammer handle with rubber guard replaced fiberglass handles (14) Nylon tie-down straps replaced heavier chains (9) Small table placed outside tool room for holding tools when entering access code (29) Floor mats installed in warehouse (2) J-hook bar obtained to pull dragline cable (16) Tractor purchased to move trailing dragline cable (16) Dragline workstation improved with larger, more adjustable armrests and a footrest (15)
New seats purchased	6	Seats changed in draglines, loaders and blades (47)
Availability of PPE improved	1	Additional knee pads stocked in warehouse (45)

^aEstimated number of employees affected by intervention.

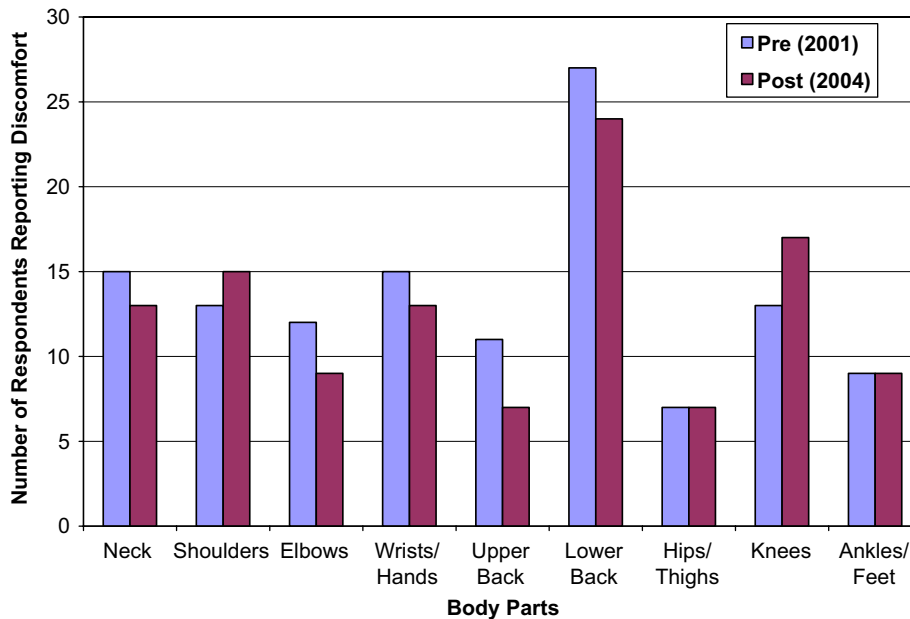


Fig. 4. Number of body part discomfort reports during the past 12 months for 2001 and 2004.

3.4. Lessons learned

When implementing new processes, there are always lessons to be learned. Lessons identified by NIOSH and the Bridger Coal Company with implementing the ergonomics process at the Jim Bridger Mine included:

- *Committee participants:* Early on in the implementation phase, a number of replacements in the leadership and

committee members occurred. The designated “champion” moved to a corporate position and a new “champion” had to be selected, and some committee members chosen to represent their departments either did not have the time or were not interested in being on the committee. Although some participant changes are inevitable, it is important to select participants who want to be a part of the process, and to allocate sufficient time for participants to perform their duties.

Table 2
Number of employees reporting discomfort in 1–4 different body parts
($n = 41$)

	Number of body parts with discomfort				Number of employees reporting any discomfort
	1	2	3	4	
2001	7	5	10	8	37
2004	6	5	7	5	31

Table 3
Percentage of employees reporting discomfort by age

	All body parts			Back		
	Age (years)			Age (years)		
	31–40	41–50	> 50	31–40	41–50	> 50
2001	100	89	100	86	65	100
2004	83	73	72	83	53	56

This later item was addressed by Bridger Coal Company by including ergonomics committee participation in the performance plans for salaried personnel, and by altering employee schedules to permit sufficient time for committee activities. Additionally, committee members supported each other by helping with tasks when other members did not have time to complete their assignments. While other companies have assigned a full-time coordinator to implement an ergonomics process, this was not considered necessary at the Jim Bridger Mine. Management at the Jim Bridger Mine was willing to put ergonomics ahead of other required duties.

- *Process development*: There is no single method when developing a process that will work for all companies. Although the Ergonomics Committee was given a lot of information and ideas on how to proceed with the process, it was necessary for the committee members to determine what would work best to meet their needs. Because the Committee had the responsibility for selecting the path it would take in implementing the process and then for ensuring its success, it was critical to have employees on the Committee who were dedicated to a successful process.
- *Process implementation*: Although the employees received training after the Ergonomics Committee developed a procedure for submitting concerns, sufficient time was not allowed for the members to become thoroughly familiar with this procedure. Because the employee training resulted in the submittal of numerous employee concerns, the members were overwhelmed with addressing these concerns while they were still getting comfortable with their procedure. Committee

members were apprehensive about the amount of time needed to address all the concerns and how the delay in responding would impact support for the process. Sufficient time should be given for a committee to become thoroughly familiar with its procedures prior to giving employee training and requesting that employees submit concerns.

- *Supervisory training*: The awareness training provided was primarily focused on employees, and did not address specific responsibilities of supervisors. Supervisors should receive additional training that specifically addresses their role in the ergonomics process. This training should demonstrate management's support for the process and be done prior to the employee training so the supervisor can support implementation of the process. Supervisory training is particularly critical for supervisors who may have employees who are reluctant to participate in the process. The concerns of these employees may never be addressed unless their supervisor initiates a report to the ergonomics committee. Additionally, it is imperative that supervisors be fully aware of the way the company plans to conduct business related to ergonomic concerns.

4. Conclusions

The ergonomics process implemented at the Jim Bridger Mine produced an active ergonomics committee backed by strong participation. The training received by management, committee members and employees led to improved interactions between employees and management regarding their thoughts on injury prevention. Employees used their knowledge of risk factors to report concerns about their jobs and their peer's jobs.

In addition to responding to employee reports of risk factors, the committee also applied its ergonomic knowledge and awareness to other processes, such as purchasing equipment, implementing new procedures, and developing new training. Committee members also reviewed reported injuries and illnesses to determine if ergonomic risk factors were associated with the injury or illness.

Employees also took the initiative to improve their jobs and reduce exposure to risk factors. For example, mechanics took action by constructing a counter balance for a 25-pound, 1½-inch impact wrench used to change out the cutting edges on a bulldozer blade. Rather than holding the impact wrench, which resulted in sore hands, arms and shoulders, the impact wrench was suspended from a crane. In addition, mechanics applied their ergonomic knowledge when evaluating new equipment. When a new lubrication truck arrived at the mine, the truck was inspected to ensure it met specifications, including ergonomic design features. Several items were identified on the truck as needing improvement, many of which were ergonomic in nature. The truck was returned to the manufacturer for modification before it was accepted by the mine.

As part of a corporate-wide initiative, the Bridger Coal Company was tasked with completing a health risk assessment designed to identify health hazards for each job classification at the mine. The health hazards initially included in this assessment were chemical and biological hazards; however, with the ergonomic knowledge gained during the past few years at the Jim Bridger Mine, the Ergonomics Coordinator added risk factors associated with MSDs. Consequently, the risk assessment tool was modified at the corporate level to include these risk factors, and served as a baseline for identifying tasks with exposures to ergonomic risk factors.

In just three years, the Bridger Coal Company implemented an effective, proactive process to reduce exposure to ergonomic risk factors. As conditions change at the Jim Bridger Mine, the process is also being modified to ensure continuing improvement and effectiveness. Instead of waiting for an injury or illness to occur prior to making changes, the Bridger Coal Company is relying upon an employee-based participative process to implement interventions that promote the well-being and comfort of its employees, and to incorporate ergonomics into many other processes affecting employee safety and health. Kean Johnson, Coordinator for the ergonomics process at Bridger Coal, stated:

Ergonomics has played an important role in helping Bridger Coal reach our goal of providing the safest and healthiest working environment possible for our employees. Our Management and hourly employees alike understand the value of what has been developed. In the beginning, when the idea of establishing such a program surfaced, we were all skeptical of just how things would work. However, thanks to the combined efforts of NIOSH, PacifiCorp, and those employees at Bridger Coal Company involved in the creation process, we found that an ergonomics program could not only be efficiently developed, but that it could be highly effective as well. The Ergonomics Program is currently an integral part of our company and we are confident that it will continue to improve and enhance the safe working experience at our mine.

Acknowledgments

NIOSH would like to thank the Bridger Coal Company and its Management for being leaders in the mining industry when addressing the ergonomic concerns of its employees. Their actions demonstrated a proactive culture that places the well-being of its employees as its first priority. NIOSH would also like to thank the members of the Ergonomics Committee and the many Bridger Coal Company employees who offered their time and effort to ensure the success of this process.

The authors also wish to thank several current and former employees of the NIOSH Pittsburgh Research Laboratory who supported this project in many different

ways. They include: Kim Cornelius, Bill Rossi, Fred Turin, Richard Unger, Charlie Vaught, and William Wiehagen.

Disclaimer: The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the National Institute for Occupational Safety and Health.

References

- Biering-Sørensen, F., 1983. A prospective study of low-back pain in a general population. I. Occurrence, recurrence, and aetiology. *Scandinavian Journal of Rehabilitation Medicine* 15, 81–88.
- Bureau of Mines, 1981. Ergonomics–human factors in mining. Proceedings: Bureau of Mines Technology Transfer Seminars, Pittsburgh, PA, December 3, 1981; St. Louis, MO, December 10, 1981; and Denver, CO, December 15, 1981. Information Circular 8866.
- Bureau of Mines, 1983. Back injuries. Proceedings: Bureau of Mines Technology Transfer Symposia, Pittsburgh, PA, August 9, 1983 and Reno, NV, August 15, 1983. Information Circular 8948.
- Bureau of Mines, 1987. Human engineering and human resources management in mining. Proceedings: Bureau of Mines Technology Transfer Seminar, Pittsburgh, PA, July 7–8, 1987; St. Louis, MO, July 15–16, 1987; and San Francisco, CA, July 21–22. Information Circular 9145.
- Butler, M., 2003. Corporate ergonomics programme at Scottish & Newcastle. *Applied Ergonomics* 34, 35–38.
- Cohen, A., Gjessing, G., Fine, L., Bernard, B., McGlothlin, J., 1997. Elements of ergonomics programs: a primer based on workplace evaluations of musculoskeletal disorders. US Department of Health and Human Services, CDC, NIOSH, Publication No. 97–117.
- Eastman Kodak Company, 1983. Ergonomic Design for People at Work, vol. 1. Lifetime Learning Publications, Belmont, CA.
- English, C.J., Maclaren, W.M., Court-Brown, C., Hughes, S.P.F., Porter, R.W., Wallace, W.A., 1995. Relations between upper limb soft tissue disorders and repetitive movements at work. *American Journal of Industrial Medicine* 27 (1), 75–90.
- Gauf, M., 1995. Ergonomics That Work: Case Studies of Companies Cutting Costs through Ergonomics. CTD News, Haverford, PA.
- Gjessing, C., Schoenborn, T., Cohen, A., 1994. Participatory ergonomic interventions in meatpacking plants. US Department of Health and Human Services, CDC, NIOSH, Publication No. 94–124.
- Guo, H.R., Tanaka, S., Cameron, L.L., Seligman, P.J., Behrens, V.J., Ger, J., et al., 1995. Back pain among workers in the United States: national estimates and workers at high risk. *American Journal of Industrial Medicine* 28 (5), 591–602.
- Hägg, G., 2003. Corporate initiatives in ergonomics—an introduction. *Applied Ergonomics* 34, 3–15.
- Hignett, S., 2001. Embedding ergonomics in hospital culture: top-down and bottom-up strategies. *Applied Ergonomics* 32, 61–69.
- Joseph, B., 2003. Corporate ergonomics programme at Ford Motor Company. *Applied Ergonomics* 34, 23–28.
- Kurionka, I., Jonsson, B., Kilbom, A., Vinterberg, H., Biering-Sorensen, F., Andersson, G., et al., 1987. Standardized nordic questionnaire for the analysis of musculoskeletal symptoms. *Applied Ergonomics* 18, 233–237.
- Moore, J., Garg, A., 1998. The effectiveness of participatory ergonomics in the red meat packing industry: evaluation of a corporation. *International Journal of Industrial Ergonomics* 21, 47–58.
- Moreau, M., 2003. Corporate ergonomics programme at automobiles Peugeot-Sochaux. *Applied Ergonomics* 34, 29–34.
- Munck-Ulfstält, U., Falck, A., Forsberg, A., Dahlin, C., Eriksson, A., 2003. Corporate ergonomics programme at Volvo Car corporation. *Applied Ergonomics* 34, 17–22.

- Occupational Safety and Health Administration, 1990. Ergonomics Program Management Guidelines for Meatpacking Plants.
- Ohlsson, K., Attewell, R., Skerfving, S., 1989. Self-reported symptoms in the neck and upper limbs of female assembly workers. *Scandinavian Journal of Work Environment and Health* 15 (1), 75–80.
- Ohlsson, K., Hansson, G.A., Balogh, I., Strömberg, U., Pålsson, B., Nordander, C., et al., 1994. Disorders of the neck and upper limbs in women in the fish processing industry. *Occupational and Environmental Medicine* 51, 826–832.
- Perry, L., 1997. Implementing company-wide ergonomics. *Workplace Ergonomics* May/June, 18–21.
- Riihimäki, H., Tola, S., Videman, T., Hänninen, K., 1989. Low-back pain and occupation: a cross-sectional questionnaire study of men in machine operating, dynamic physical work, and sedentary work. *Spine* 14, 204–209.
- Scharf, T., Vaught, C., Kidd, P., Steiner, L., Kowalski, K., Wiehagen, B., et al., 2001. Toward a typology of dynamic and hazardous work environments. *Human and Ecological Risk Assessment* 7 (7), 1827–1841.
- Schutte, P.C., 2005. Ergonomics in the South African mining industry. *The Journal of the South African Institute of Mining and Metallurgy* 105 (6), 369–372.
- Smyth, J., 2003. Corporate ergonomics programme at BCM Airdrie. *Applied Ergonomics* 34, 39–43.
- Steiner, L.J., Cornelius, K.M., Turin, F.C., 1999. Predicting system interactions in the design process. *American Journal of Industrial Medicine* 36, 58–60.
- Steiner, L.J., James, P., Turin, F.C., 2004. Partnering for successful ergonomics: a study of musculoskeletal disorders in mining. *Mining Engineering* 56 (11), 39–44.
- Straker, L.M., 1990. Work-associated back problems: collaborative solutions. *Journal of the Society of Occupational Medicine* 40, 75–79.
- Straker, L., Burgess-Limerick, R., Pollock, C., Egeskov, R., 2004. A randomized and controlled trial of a participative ergonomics intervention to reduce injuries associated with manual tasks: physical risk and legislative compliance. *Ergonomics* 47 (2), 166–188.
- Toomingas, A., Hagberg, M., Jorulf, L., Nilsson, T., Burnström, L., Kihlberg, S., 1991. Outcome of the abduction external rotation test among manual and office workers. *American Journal of Industrial Medicine* 19 (2), 215–227.
- US Government Accounting Office, 1997. Worker protection: private sector ergonomics programs yield positive results. GAO/HEHS-97-163.