JOB DESIGN: AN EFFECTIVE STRATEGY FOR REDUCING BACK INJURIES

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ABSTRACT

The U.S. Bureau of Mines conducted research to reduce musculoskeletal injuries. Occupationally related musculoskeletal injuries pose a significant problem to the mining industry. Ergonomics can help to reduce the costs associated with these injuries. Mines can institute committees to solve ergonomic problems. These committees should include representatives from management, the labor force, and the medical department. Various analysis techniques, such as job safety analysis, task analyses, materials-handling flowcharts, and preliminary hazards analysis can be used to identify ergonomic problems in and around a mine.

Once hazards have been identified, then solutions can be formulated and implemented. The preferred strategy is to redesign the job by eliminating the hazard, removing the worker from exposure, or mechanizing the task. If these strategies are infeasible, then the job should be designed so that it can be performed within the workers' capabilities. After any ergonomic solution is implemented, a followup analysis should be performed to ensure the effectiveness of the change and to guard against the introduction of any new ergonomic or safety hazards. Physical fitness programs and training can be used to supplement job redesign. By effectively instituting sound ergonomic implementation strategies, the costs associated with musculoskeletal disorders can be reduced.

INTRODUCTION

The U.S. Bureau of Mines (USBM) has undertaken research to reduce musculoskeletal injuries as part of its mission to improve the health and safety of the Nation's miners. Given the unique hazards in mining such as cramped work spaces, rocky and uneven walking surfaces, walking surfaces covered with water, hot and cold temperatures, low levels of lighting, and rough terrain over which heavy vehicles operate (*12*),[3] one would expect that musculoskeletal injuries are a major portion of all injuries in mining. According to an analysis of all underground coal mining accidents from the 1991 U.S. Mine Safety and Health Administration (MSHA) accident database, 34% were classified as sprains or strains, 21% occurred to the back, 24% were due to "overexertion," and 24% involved the handling of materials.

In addition to the pain and human suffering created by these injuries, they result in a significant amount of lost time and, hence, lost productivity and contribute to high health care and compensation costs. In fact, Plummer, (*14*) reported that back injuries alone account for close to 20% of all payroll dollars. According to an informal USBM analysis, in 1991 the average coal mining back injury cost over $8,400 and the total cost to society for coal mining back injuries was over $30 million.

Many musculoskeletal injuries are a result of cumulative trauma, or wear and tear that occurs over a relatively long period of time (*8*). One science that deals with the reduction of such injuries is ergonomics, the study of how human beings relate to their work environment. By using ergonomics, the occurrence of musculoskeletal disorders in the workplace can be reduced. One approach that has

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been successfully used by the general industry, and the mining industry as well, to combat musculoskeletal injuries is to establish an ergonomics committee. O'Green (*13*) reported a 41% reduction in back injuries over a 4-year period after the establishment of ergonomics committees at the mine sites studied. These ergonomics committees can form the basis of a successful ergonomics program.

ERGONOMICS COMMITTEES

The implementation of a successful ergonomics program into the workplace usually requires a multidisciplinary approach. A number of individuals from throughout the mining company should participate. A team approach should be used where a committee is established to provide a forum for the exchange of ideas and the execution of strategies to solve ergonomic problems.

Effective committees should include management, labor, engineering, maintenance, personnel, and front-line employees; furthermore, support from each of these groups must be secured. In addition, the mine medical personnel and the safety specialist or corporate ergonomist should take part. Educating those involved is of utmost importance. According to Pope (*16*), it is crucial that all personnel be informed about "methods, goals, risk factors, and the possibility of prevention." Small mine operators may not have access to all of these personnel, but the committee should be comprised of as many of the above as is feasible.

Including representatives from the front-line work force is a key element to the success of an ergonomics committee. Imada (*10*) outlines three reasons workers should be included in the ergonomic problem-solving process. He states that the workers are already aware of ergonomic principles and ergonomics simply provides labels for ideas already in use. Second, he reports that the likelihood of successful implementation of ergonomics is increased if the worker has some ownership in the ideas. Finally, Imada asserts that by the end-user implementing the technology, he or she "will be able to modify it to solve future problems," thus providing long-term benefits.

Often times, the mine management must be sold on the idea of using ergonomic intervention strategies. A particularly good argument for the use of these strategies can be made through a cost-benefit analysis (*15*). When performing such an analysis, one must include both direct and indirect (or hidden) costs. Direct costs include such items as medical expenses, worker compensation, and liability costs. Indirect costs often outweigh direct costs and include such items as lost productivity, cost of rehiring and retraining a new employee, and loss of employee morale (*5*).

IDENTIFYING PROBLEMS

After the infrastructure is in place and support is secured, the next task is to identify ergonomic problems through various analysis techniques. These analyses can vary in sophistication from informal conversations with employees to more formal techniques, such as job safety analyses. An excellent place to start identifying ergonomic problems is by examining the company safety records. By making a table of incidence rates by job classification, activity at the time of the occurrence, type of injury, etc., one can identify particular jobs or activities that contribute to the most musculoskeletal injuries. One must keep in mind, however, that musculoskeletal injuries are often a result of cumulative trauma; so assigning a single cause to a particular claim may be erroneous in many cases.

After the records are examined, the committee can then rank the jobs and the activities that need to be examined. Prime candidates for job redesign are those jobs that have a particularly high frequency of injury or those activities that result in particularly severe trauma. The jobs should be ranked by the committee and the jobs with the most severe ergonomic problems should be analyzed first.

Task analyses can then be performed so that ergonomic hazards associated with a particular job or task are identified. These analyses usually involve describing in detail each motion or action required to execute a task. By closely examining each motion or action, the ergonomic stressors or the risk factors associated with a job can then be identified. Andersson (*1*) outlines the following work attributes as risk factors for low-back pain: heavy physical work, static (not moving) work postures, frequent bending and twisting, lifting and forceful movements, repetitive work, and vibration.

One particular type of task analysis, job safety analysis, has recently received much attention in the mining industry and is ideally suited for identifying and correcting ergonomic hazards. MSHA (*20*) has developed a set of guidelines that detail the job safety analysis process for the mining industry. The guidelines detail four basic steps involved with a job safety analysis: (1) Select the job to be analyzed, (2) separate the job into its basic steps, (3) identify the hazards associated with each step, and (4) control each hazard. By using this method, accidents can be prevented by foreseeing and abolishing accidents before they happen.

Since many ergonomic hazards in mining result from manual materials handling, Gallagher (*6*) suggests that the materials supply-handling system be examined in addition to the jobs. A flowchart can be developed that represents the movement of supplies from the delivery at the mine to the supply item's end use. By closely examining the flowchart, unnecessary manual materials handling can be identified and eliminated, thus reducing the miners' exposure to lifting hazards. Figure 1 presents an example of flowcharts for handling concrete blocks at two different mines. There is much manual handling of the materials in mine A, while the blocks are handled mechanically until their end use in mine B.

Daling (*3-4*) has outlined safety analysis techniques that are useful for the mining industry, based upon certain criteria that the techniques must meet. The methods should not be too complex and should apply to most mining situations. Furthermore, the methods should be able to generate checklists and be cost effective. One of the hazard identification analyses identified as suitable for the mining industry that could be used to identify ergonomic hazards is the preliminary hazards analysis.

According to Hammer (*9*), the preliminary hazards analysis is broad in scope and performs the following functions: (1) identifies possible hazards, (2) looks for ways to eliminate the hazard, and (3) if the hazard cannot be eliminated, investigates the best way to control it. A form is often developed where the hazard, contributing events, estimated probability, and means of control are listed. Hammer suggests a procedure of "signing off" on the form once the proper controls are taken so that these controls are sure to be carried out. Furthermore, Daling (*4*) warns of the dangers of the analyst simply filling out the form and caution that the analyst pay attention to subtle items and minute details.

The mine worker should not be overlooked as a valuable resource when identifying ergonomic stressors. Asking the miner to explain conditions that contribute to ergonomic hazards can often provide enlightening information, since the miner probably knows the job requirements and methods better than anyone. The miner may have already changed the workplace to lessen an existing problem that could result in an ergonomic stressor.

One effective means of getting information about possible ergonomic deficiencies from miners is with the critical incidence technique. This method collects data based on "hazards, near-misses, and unsafe conditions and practices from operationally experienced personnel" (*9*). The miner is asked about events that have happened to him or her or that he or she has seen first hand, similar to an accident investigation. If the critical incident technique is used to identify ergonomic problems, the work force must be informed about ergonomic principles. Once the ergonomic hazards have been identified, then solutions must be developed to eliminate or reduce the risk of these hazards.

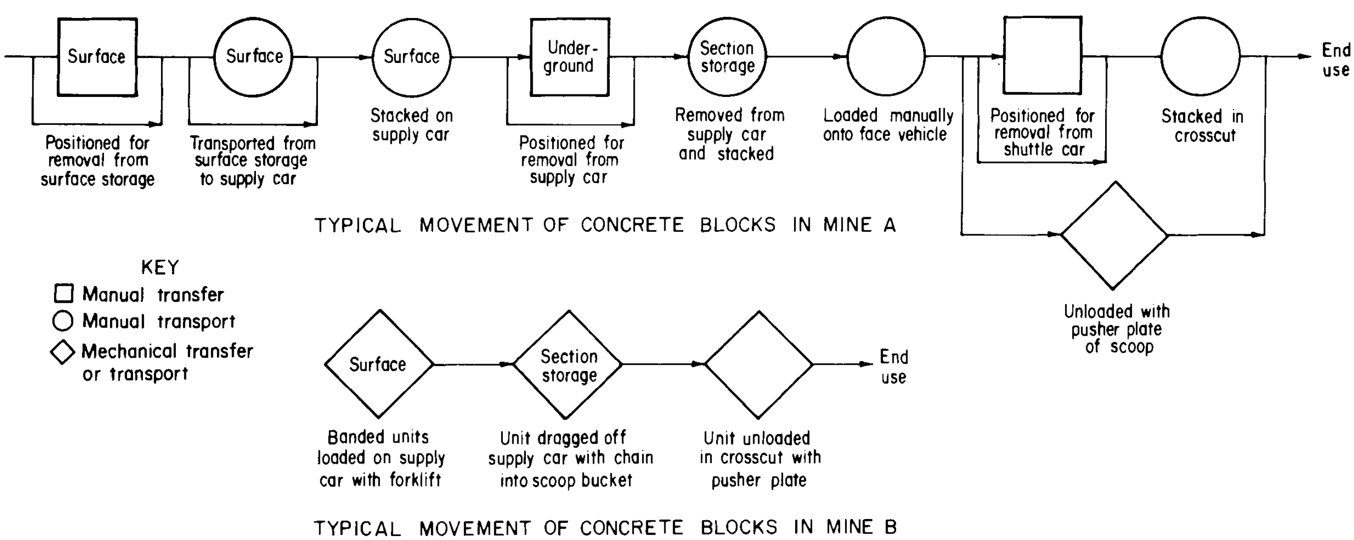

Figure 1.—Flowchart of concrete block transportation at two mines.

DEVELOPING SOLUTIONS

Gallagher (*6*) presents a model for solving materials-handling problems (fig. 2); this model can be used to get rid of other ergonomic stressors as well. The ergonomic problem-solving strategies in the model include redesigning the job, using worker selection procedures, and training the work force in proper work methods.

The preferred solution to any ergonomic problem is to eliminate the hazard or remove the miner from any exposure. Proper planning can eliminate the need to perform a task at all. Gallagher (*6*, p. 25) provides an example in which an underground coal mine cut the number of manual lifts required to deliver a supply car of materials from 800 to 400 by keeping the supplies on the supply car during storage. This solution requires the purchase of an additional supply car, but can result in great savings by reducing the direct and indirect costs associated with occupational low-back pain.

If the hazard cannot be eliminated, the miner can be removed from any exposure to the hazard. For example, if a continuous miner operator is being exposed to dangerous levels of whole-body vibration while seated in a machine cab, the task could be redesigned so that the miner operates the machine from outside the cab using a remote control. The miner would then be removed from the vibration exposure.

The next strategy that should be considered to redesign the job, providing the previous strategies cannot be used, is to mechanize the task. One requirement for any piece of mechanized equipment is that it be rugged enough to withstand the harsh mining environment. Conway (*2*) has provided plans for six mechanical-assist devices that can be used to eliminate lifting associated with some underground mining tasks. These devices can be easily fabricated in most mine shops and include such items as a timber car, a scoop-mounted lift boom, and a container-work station vehicle. If the above strategies cannot be carried out, then the job must be designed so that it can be performed within the miners' capabilities. For example, it may not be possible to entirely eliminate a miner's exposure to whole-body vibration. However, the vibration levels should be lessened so that they are within existing standards. Furthermore, manual materials-handling tasks can be designed to fit the miners' capabilities.

The National Institute for Occupational Safety and Health (NIOSH) (*11*) provides guidelines for manual lifting that can prove useful for many situations in mining. Lifting capacity can be significantly lower, however, if the task is being performed in low coal, where the miner must work in constrained postures (*7*). One way that tasks can be designed to fit within a worker's capacity is to reduce the weight of the object being lifted. For example, Gallagher (*7*) reports that rock dust packaged in 18-kg (40-lb) bags is a more appropriate size than 23-kg (50-lb) bags, given the reduced lifting capacity in restricted postures.

After any ergonomic solution is carried out, it is crucial that a followup analysis be performed. This followup is done to ensure that all ergonomic problems in the original job design are resolved and to guard against the introduction of any new ergonomic or safety hazards.

According to Snook (*19*), worker selection and training techniques alone are not an effective control for low-back injuries and the ergonomic redesign of jobs and workstations is the preferred approach. However, it is often "impractical, if not impossible, to design a job in such a manner that no training was required" (*17*). Thus, training should be an integral part of an effective ergonomics program. Furthermore, ergonomics training should be given to those workers who are serving on the ergonomics committee, as expressed earlier. Training should include an introduction to biomechanics (including safe lifting), anthropometry, and work physiology. In addition, ergonomic stressors common to mining, such as thermal stress, vibration, noise, and lighting, should be discussed. Annual refresher training could provide an excellent forum for such instruction.

Another strategy that supplements job redesign strategies to reduce occupationally related musculoskeletal injuries is the implementation of an exercise program. Exercise leads to improved strength and cardiovascular fitness that can, in turn, lead to a reduction in the costs associated with musculoskeletal injuries. However, one must be care-ful when implementing such a program: Gallagher (*6*, p. 28), advises that "the worker should consult with a physician prior to participation in any exercise program."

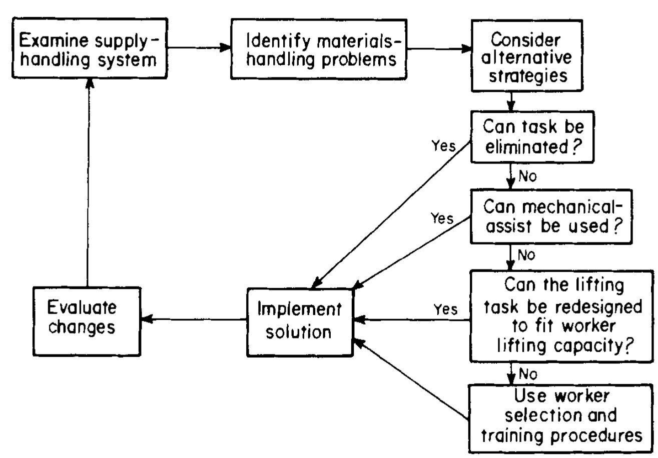

Figure 2.—Model for redesigning materials-handling tasks.

CONTROL OF COSTS ONCE BACK INJURY HAS OCCURRED

The previous sections have detailed methods that can be useful in preventing low-back injuries. However, it is important for management to realize that some back injuries probably will occur, despite efforts to prevent them. When back injuries do occur, the policy that management puts in place to deal with the injury may have a significant role in determining the duration of the disability and the costs incurred by the company.

As discussed by Snook (*18*), management often does not respond properly when workers experience a back injury. The injured worker may be accused of malingering either by direct accusation or through innuendo. This, in turn, causes the workers to look for ways to get back at management. As such adversary situations develop, the costs of the injury may significantly increase for both the worker and management. However, as discussed by Snook (*18*), studies have indicated that enlightened management can often reduce and perhaps even prevent the disability associated with low-back pain through a program that includes positive acceptance of low-back pain, early intervention, good communication and followup, and early return-to-work programs.

POSITIVE ACCEPTANCE OF LOW-BACK PAIN BY MANAGEMENT

The most appropriate response by a supervisor to a back injury experienced by one of his or her workers is to show concern for the needs of the employee, and to avoid making rash judgments and setting up adversary relationships because of the injury. Such judgments are usually incorrect and may serve to make the situation worse than it should be. Instead, management should be trained to realize that a certain number of back injuries are likely to occur and should be taught to respond in an appropriate manner when they do occur. The supervisor should encourage the worker to seek immediate medical treatment and (if possible) adapt the workplace or modify the task so that the employee can continue to work on the job. One company that instituted a policy of positive acceptance of low-back pain immediately and dramatically reduced its worker compensation costs. Over a 3-year period, costs were reduced from over $200,000 per year to about $20,000 per year (*18*).

EARLY INTERVENTION

One key feature of the program described above was the fact that all workers complaining about low-back pain were immediately referred to the company clinic for treatment—even those with minor complaints. Treatment was given during work time by the company nurse. This treatment consisted of heat applications and nonprescription analgesic-anti-inflammatory drugs, such as aspirin. During the treatment sessions, worker education was initiated on a one-to-one basis. The education program consisted of basic spinal anatomy and physiology, the expected results from the treatment regimen, proper posture, and suitable exercises. Light-duty work and rest periods were provided by management to the injured employee. If the initial in-house treatment was ineffective, the worker was referred to the company physician for further medical treatment. The physicians were familiarized with the physical demands of the jobs at the company to place injured workers in appropriate job positions.

Because this company encouraged the reporting of all episodes of low-back pain (even minor cases), it is not surprising that the number of cases reported actually increased. However, the amount of lost time due to low-back pain was significantly reduced. This indicates that the workers were able to stay on the job and did not rely on outside practitioners for treatment, thus reducing the company's cost because of low-back pain.

FOLLOWUP AND COMMUNICATION

When workers do become temporarily disabled, it is important that management establishes and maintains good communications with the worker and appropriate medical personnel. Supervisors should be instructed to followup every disability case with a telephone call or visit before 2 days of lost time have elapsed. The purpose of the call is to let the worker know that the company is concerned and to inform the supervisor of the status of the worker's recovery.

One company recently instituted a program that increased the communication between the worker, employer, practitioner, and insurer (*18*). When a worker-compensation claim was received, the employer made immediate contact with the worker and insurer and followed up with calls at regular 10-day intervals to make certain that the claim was progressing smoothly. The possibility of retraining was explored for extended claims, and a liaison was established between management and the insurer if a gradual return to work was indicated. The focus of all communications was that every action taken was in the best interest of the worker. This program significantly reduced the proportion of long-term worker's compensation claims and also significantly reversed a trend of increasing accident rates (*18*).

EARLY RETURN-TO-WORK PROGRAMS

The data from several studies have shown that the longer a worker is off from work because of a back injury, the less likely the worker will be able to return to productive employment. These studies underscore the importance of providing modified, alternative, or part-time work to the injured employee to facilitate a quick return to the job. Unfortunately, management will often extend the period of disability by requiring workers to be fully recovered before returning to work. This policy can often be more costly than providing modified, alternative, or part-time employment to the injured employee. Because there appears to be a limited amount of time to act before losing control of the disability and the claim, efficient management should do everything in its power to encourage the worker's timely return to work. Data indicate that an early return to work is in the best interests of everyone: the worker, the company, and the union. In this regard, it may benefit both the company and the union to ensure that work rules in the current contract do not interfere with early return-to-work programs.

SUMMARY

Occupationally related musculoskeletal injuries pose a significant problem to the mining industry, and ergonomics can help to reduce the costs associated with these injuries. Mines can start committees to solve ergonomic problems. These committees should include representatives from management, the labor force, and the medical department. Various analysis techniques, such as job safety analysis, task analyses, materials-handling flowcharts, and preliminary hazards analysis can be used to identify ergonomic problems in and around a mine.

Once hazards have been identified, then solutions can be formulated and realized. The preferred strategy is to redesign the job by getting rid of the hazard, removing the worker from exposure, or mechanizing the task. If these strategies are infeasible, then the job should be designed so that it can be performed within the workers' capabilities. After any ergonomic solution is implemented, a followup analysis should be performed to ensure the effectiveness of the change and to guard against the introduction of any new ergonomic or safety hazards. Physical fitness programs and training can be used to supplement job redesign. By effectively instituting sound ergonomic implementation strategies, a healthier work force can be maintained and the costs associated with musculoskeletal disorders can be reduced, thereby reducing health care and compensation costs.

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