Ergonomic Evaluation
Part of a Treatment Protocol for Musculoskeletal Injuries

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Abstract

Ergonomic analyses and interventions are used as primary prevention methods to reduce physical stressors in the workplace and to prevent work-related musculoskeletal disorders (WMSDs). These methods can also be used for the treatment of injured employees. In this study, 103 employees with WMSDs resulting in more than 5 days away from usual work received an ergonomic evaluation which consisted of observation of usual work tasks, recommendations to minimize identified stressors, and case coordination. The goal of the intervention was to make simple job changes that would assist employees to return safely to usual job duties. The process for implementing this protocol for health care, airline, and university employees is described. The results show that after ergonomic evaluations were performed, the majority of recommendations were fully or partially (89%) implemented. Behavior changes were more likely to occur than administrative and equipment changes ($p < .001$). Occupational health nurses can use a similar program to enhance treatment plans for clients with WMSDs.

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Work-related musculoskeletal disorders (WMSDs) such as back pain, sprains and strains, and carpal tunnel syndrome affect an estimated 19 million individuals per year in the United States, represent approximately one third of all occupational injuries and illness, are responsible for more than one third of lost workday cases, and account for the majority of workers’ compensation costs nationwide (Bernard, 1997; U.S. Department of Labor, 2003a; Webster, 1994). It is estimated that WMSD cost employers more than $15 billion annually, and when other related expenses are included, this cost may be as high as $54 billion a year (U.S. Department of Labor, 1999). Costs in the workers’ compensation system include health care expenses to cover treatment of injured workers, temporary disability payments to compensate lost wages, and permanent disability settlements.

There is general recognition that the physical demands of work are an important risk factor in the development of WMSDs. Physical risk factors such as high force demands, frequent repetition, awkward postures, and vibration are associated with WMSDs in many studies (Alcouffe, Manillier, Brehier, Fabin, & Faupin, 1999; Bernard, 1997; Institute of Medicine, 2001; Punnett, Gold, Katz, Gore, & Wegman, 2004). In the growing field of workplace ergonomics, it is recognized that reduction in specific workplace physical demands will help prevent WMSDs, and may increase efficiency and productivity. Many ergonomic efforts have been aimed at primary prevention of WMSDs among asymptomatic employees. However, employees with symptomatic WMSDs may also benefit from evaluation of their workplaces for identification of physical stressors that can be eliminated. Simple modifications often can be made to a workplace that enables the work to be completed with less effort on the part of the employee. Such modifications, where possible, may enable employees to return...
METHODS

Study Participants

Participants were recruited from three large Midwest employers—a large acute care hospital system, a major airline company, and a large university. These industries were targeted because of the high rates of WMSDs reported in health care and the airline industry (U.S. Department of Labor, 2003b) and the wide range of jobs performed by university employees. The majority of health care workers were responsible for direct client care activities (e.g., registered nurses, nursing aides, respiratory therapists), but also included office workers and employees from dietary, maintenance, and housekeeping departments. Airline ground crew included baggage handlers, commissary workers, mechanics, and ticket agents. The sample of university employees consisted primarily of maintenance workers, nursing personnel, and laboratory and research technicians. Eligible participants from these employers were those working at least 20 hours per week who had a documented WMSD resulting in 5 or more days of lost work (i.e., inability to perform any work) or restricted duty (i.e., inability to perform usual work). Injuries included both disorders related to repetitive work activities and acute injuries such as sprains and strains.

Eligible employees were identified through the clinical information system at the treating occupational health clinics and the workers’ compensation coordinator or the occupational health nurse at each study site. Eligible participants were contacted by telephone and were invited to participate. Informed consent was obtained over the telephone. Participants were mailed a copy of the written consent form for their personal records, if they agreed to participate. The Washington University in St. Louis Institutional Review Board approved this study.

Onsite Ergonomic Evaluation

A certified ergonomist performed the ergonomic evaluation shortly after the employee sought treatment for the WMSDs. The evaluation was conducted at the worksite with the active participation of the injured employee and, when possible, the employee’s supervisor. The purpose of the evaluation was to identify easily remediable physical stressors and feasible engineering or administrative solutions that would reduce physical work demands.

To obtain an accurate description of the risk factors associated with the job, the ergonomist interviewed the injured employee and the employee’s supervisor. The interview focused on the employee’s history related to the injury, current restrictions, the type of accommodations used and available to the worker, as well as any past attempts at reducing perceived or identified stressors. In addition, when not prohibited by restrictions, the employee was observed performing usual job tasks.

In addition to briefly assessing overall job exposures, the ergonomist targeted two specific job tasks. These tasks were identified by asking injured workers to state which tasks they found most difficult to perform as a result of their injuries. The goal was to target jobs that workers found physically stressful, and identify and implement recommendations that would reduce or eliminate the stressors. It was believed that targeting specific tasks employees found difficult to perform would aid in employees’ return to usual work duties. Examples of identified risk factors include awkward postures, repetitive motions, high force requirements, and extended reach. Easily implemented solutions, such as moving equipment for easier access or relieving awkward postures, were made during this assessment. In addition to worksite changes, the ergonomist provided employees with explanations of the reasons for and benefits of the changes, and instructed employees on proper body mechanics and work techniques for their specific job tasks.

A written report with specific employee and supervisor recommendations was generated upon completion of the evaluations. Only recommendations thought feasible to implement were included in the written report. This report was mailed to the employee’s supervisor, health care providers, and occupational health representative. Employees received only the section of the report describing their responsibilities.

Case Coordination

In addition to receiving the written report, a research nurse experienced in occupational health and case management verbally reviewed the findings and recommendations from the ergonomic evaluation with the employee, supervisor, health care provider, and occupational health representative. The role of the research nurse was to ensure that all parties involved in the employee’s workers’ compensation case were aware of the specific job demands of the employee, understood the employee’s capabilities, were informed about available options for workplace change, and were able to facilitate the implementation of the ergonomist’s recommendations. The underlying goal was to support the

to their usual jobs faster and may prevent re-injury. This, in turn, would reduce disability and costs associated with workers’ compensation claims. A number of authors have advocated the importance of ergonomic changes in treating employees with WMSDs (Arnetz, Sjogeren, Rydehn, & Meisel, 2003; Bernacki, Guidera, Schaefer, Lavin, & Tsai, 2000; Feuerstein et al., 1993; Higgs & Mackinnon, 1995; Melhorn, 1996; Norris, 1993).

This study incorporated an individual ergonomic evaluation with suggestions for worksite modifications, which included case coordination services, into the treatment plans for injured workers. The goal was to identify ways to alter the worker’s job so that the injured worker could perform job functions while maintaining work-related restrictions. The purpose of this article is to describe the implementation of the ergonomic evaluation program, including the extent to which recommendations generated from this program were implemented in the workplace.
employee’s safe return to usual job duties without violating work-related restrictions.

Direct dialogue with the employee and supervisor allowed the research nurse to determine if the ergonomist’s recommendations were being implemented or if assistance was needed to make the recommended changes. Reviewing the ergonomist’s evaluation with the health care provider ensured that the health care provider understood the specific job demands of the client and what types of accommodations were possible within the workplace. The research nurse attempted to communicate with the injured employee on a weekly basis to address employee concerns as well as reinforce adherence to suggested behavior changes. Weekly calls ended after the employee was released to full duty and discharged from health care.

Follow-Up Ergonomic Evaluation
Six months following the first worksite visit, a follow-up ergonomic evaluation was performed to determine if recommended changes had been implemented. As before, the ergonomist observed the employee perform usual work duties, when possible, to identify specific worksite and behavior changes. Interviews were conducted with the employee and supervisor to determine if additional changes had occurred that were not observed. Because the employee’s supervisor was responsible for implementing some of the ergonomist’s recommendations, the employee’s supervisor was interviewed to determine which, if any, of the recommendations had been incorporated into the workplace, even if the employee left the company prior to the follow-up evaluation. In some cases it was not possible to interview the supervisor, and, therefore, it is unknown if changes were made.

Implementation of Recommendations
After both ergonomic evaluations were completed, three members of the research team reviewed the written reports to determine the degree to which the original recommendations were implemented (i.e., Fully, Partially, Not at All, Not Applicable, or Not Known). A rating of Fully meant all recommendations were implemented and consistent behavior changes were observed and reported. If equipment changes were partially made, change was in progress at the time of evaluation, or if the employee adopted some behavior changes, a score of Partial was given. A Not at All rating was given if no changes were made to the work or work environment. Because of changes in work organization and employees changing positions within the company, some recommendations were no longer applicable and rated as such. In some cases, it was not known if recommendations were implemented, and were rated as such. Recommendations were classified as either behavioral or administrative and equipment changes.

Statistical Analyses
The chi-square test was used for all statistical analyses. A p value of less than .05 was considered statistically significant. Analyses were performed using Statistical Package for the Social Sciences software (SPSS Inc., Chicago, IL).

RESULTS
Study Participants
Study participants were contacted and invited to participate after they sought treatment for a WMSD. On average, enrollment in the study occurred 5 days after treatment was obtained. Data collection occurred during a 36-month time period. This sample consisted of 153 participants. Within this group, 20 participants withdrew or were withdrawn from the study. Participants withdrew from the study because they refused the worksite evaluation or their attorney advised against study participation. Participants were withdrawn from study participation if employees’ injuries were originally classified as work-related but later reclassified as non-work-related, or if they were instructed to be on light duty for 5 days or more but did not adhere to the health care providers’ orders.

Of the 133 remaining participants, 86% of employees had an acute WMSD, which was defined as a disorder causing symptoms for 7 days or less prior to the employee reporting the injury. Fourteen percent of individuals had a chronic WMSD with symptoms lasting more than 7 days prior to reporting the injury. Examples of acute WMSDs included sprains and strains, acute back pain, or contusions. Chronic WMSDs included carpal tunnel syndrome and chronic back pain.

Ergonomic Evaluations and Case Coordination
Although the ergonomist attempted to perform pre- and post-evaluations for all study participants, some could not be performed because the employee refused, the employee had not returned to work, or the employee was deceased. A total of 103 participants received both evaluations, and they were included in the analysis. Participants were not removed from this group if they or their supervisor failed to respond to the nurse researcher’s weekly telephone calls.

Description of the Sample
Sixty-six (64%) of the participants were women and 37 (35%) were men. Of the 103 participants, 59 were employed by the health care system, 37 by the airline, and 7 by the university. The Table lists the anatomic distribution of WMSDs. If the employee could not be located for the follow-up evaluation, the ergonomist attempted to speak with the employee’s supervisor to ascertain which recommendations had been integrated in the workplace (n = 6). Because of changes in airline security after September 11, 2001, direct observation of airline jobs was not possible. In these cases, the evaluation was completed with the participant via the telephone (n = 8).

At the time of the first evaluation, 75% of workers had documented work restrictions that prevented them from doing all of their usual tasks. Therefore, only job tasks that did not violate health care provider orders were observed. To understand the work process and the risk factors involved in performing the unobserved tasks, the injured employee was asked to describe the task in detail, and to mimic the motions involved in performing the task. When available, the ergonomist observed an uninjured employee doing the specific work task. Individuals who were off from work (i.e., the health care provider ordered the employee...
to stay home from work or the workplace was unable to accommodate the restrictions) received the ergonomic evaluation after they returned to the workplace (n = 35). Direct observation of all work tasks occurred for the 25% of workers without restrictions. Permission from the worker’s supervisor was always obtained prior to the worksite visit. The supervisors were also invited and encouraged to participate in the evaluation. However, in many cases, they were unable or unwilling to participate.

The initial ergonomic evaluation was conducted approximately 10 days following study enrollment. This evaluation focused on general work tasks as well as two tasks that the injured employee identified as most difficult to perform as a result of the injury. All recommended changes were intended to create a physically less demanding job for the employee. When possible, immediate changes were made to the work area. For instance, if the ergonomist saw that the employee’s neck was in an extended position when working on a computer, adjustments were made to the workstation during the evaluation. In addition, the research nurse called the participant weekly to discuss any concerns, to monitor the progress of implementing workplace changes, and to reinforce adherence to suggested behavior changes. On average, employees received calls for approximately 7 weeks. Communication with the supervisor and the treating health care provider occurred once or twice during this time frame.

Among the 103 employees, recommendations were made for 243 job tasks or approximately 2 tasks per worker (mean number of job tasks per employee for health care was 2.55, for airline was 1.89, and for university was 2.86). These recommendations were classified as either behavioral changes or administrative and equipment changes. In 210 of 243 job tasks, recommendations were made for behavioral changes and in 124 of 243 recommendations were made for administrative and equipment changes. In some cases, both behavioral and administrative and equipment recommendations were made for a specific job task.

Follow-up ergonomic evaluations were conducted at 6 months to determine if any changes had been made in the workplace. For 89.3% of employees, the ergonomist’s recommendations were fully or partially implemented. For 10.7% of employees, recommendations were not implemented at all. Overall, differences in implementation between companies were not statistically significant (p < .49) (Figure 1).

Employees were responsible for implementing the recommended behavior changes. These changes were typically very practical, easily adopted suggestions. Examples of these recommendations included:

- Using available equipment (e.g., mechanical client-lift devices).
- Changing body positions (e.g., push rather than pull) (Picture A).
- Altering work pace (break-up repetitive tasks).

For 90.8% of employees, behavioral recommendations were fully or partially implemented. Health care and university employees were more likely to fully implement the recommendations compared to airline ground crew. Differences in proportions of employees who made behavioral changes trended toward statistical significance when compared across companies (p < .059) (Figure 2).

The supervisor was responsible for implementing administrative and equipment recommendations. Examples of these recommendations included purchasing new equipment, redesigning workstations, and allowing employees to take breaks and rotate job tasks (Picture B-C). For 69.4% of the employees, administrative and equipment changes were fully or partially implemented. The three companies differed in the proportion of cases where changes were made (p < .018) (Figure 3). Behavior changes were significantly more likely to be implemented than administrative and equipment changes (p < .001).

**DISCUSSION**

Focusing on injured workers’ capabilities can create opportunities that allow them to return to productive, meaningful work. In turn, this focus can reduce workers’ compensation costs, decrease the likelihood that the worker never returns to work, and improve health and functional status (Anema et al., 2004; Arnett et al., 2003; Bernacki et al., 2000; Hashemi, Webster, Clancey, & Volinn, 1997). In this study, individuals who were unable to perform usual work activities as a result of a compensable WMSD were eligible for study participation. These injured workers received case coordination services by a research nurse, an on-site ergonomic assessment shortly after seeking treatment for a WMSD, and a 6-month evaluation to determine what, if any, workplace changes resulted from the ergonomic assessment. The purpose of this study was to identify job activities the worker was unable to perform because of work restrictions and determine if the stressors associated with these job tasks could be reduced or eliminated to accommodate the worker’s abilities. This article describes the degree to which the

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**Table**

Anatomic Distribution of Work-Related Musculoskeletal Disorders (WRMD) Injuries

<table>
<thead>
<tr>
<th>Injured Body Part</th>
<th>All Participants</th>
<th>Health Care Employees</th>
<th>Airline Ground Crew</th>
<th>University Employees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper extremity</td>
<td>40</td>
<td>20</td>
<td>16</td>
<td>4</td>
</tr>
<tr>
<td>Lower extremity</td>
<td>21</td>
<td>12</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>Back</td>
<td>42</td>
<td>27</td>
<td>12</td>
<td>3</td>
</tr>
</tbody>
</table>

Note. Some participants had multiple injuries—randomization was based on primary symptoms.
ergonomic recommendations were implemented within the three companies studied.

The essential component of this study was the onsite ergonomic evaluation, which focused on the individual worker, specific job tasks, and individual capabilities. Risk factors associated with the injured worker’s job were identified through direct observation of work processes. Workers were also asked to articulate their concern(s) about specific job tasks they were unable to complete because of their WMSDs. Recommendations for change targeted these risk factors and only changes that were thought to be feasible were formally recommended.

Because the goal was to make simple, immediate changes that would benefit the individual worker, many recommendations focused on workers’ behavior and how they performed specific work tasks. In the majority of cases (90.8%), workers were able to completely or partially incorporate the behavior changes into their jobs. Several possible reasons could explain this success—the main reason is that study participants had direct input into the ergonomic evaluation. The participants were asked to identify problem areas and what recommendations, designed to reduce or eliminate the problems, were likely to occur. These results are supported by other studies, which have shown that change is more likely to arise if employees are directly involved in the intervention process (Bohr, Evanoff, & Wolf, 1997; Evanoff, Bohr, & Wolf, 1999; General Accounting Office, 1997; Gjessing, Schoenborn, & Cohen, 1994).

The recommendations were easy to implement and this probably resulted in increased comfort for the workers. The study team believes the workers adopted these changes because they had direct control over their behavior and did not need to rely on others for change to occur. The workers knew the goal of this project was to create a safer working environment that would facilitate return to full duty work. Therefore, it is possible that the workers in this group employed the ergonomist’s recommendations because they were motivated to return to work. Finally, recommendations for change were reinforced several times. In addition to receiving one-on-one training during the onsite visit (which typically lasted 45 to 60 minutes), the research nurse frequently reviewed the ergonomist’s recommendations with the worker throughout the recovery period.

Administrative and equipment changes were less likely to be implemented than behavior changes (69.4% vs. 90.8%) because the administrative and equipment changes tended to be more costly, required more time to implement, and frequently required the involvement of individuals other than the supervisor and employee. One goal in this study was to include supervisors in every evaluation because their support is a key element in a successful ergonomic program (General Accounting Office, 1997; National Institute for Occupational Safety and Health, 1997). Even though permission from the supervisor was always...
obtained prior to the workplace visit, managerial support for the study varied among employers and between different work units within the three employers, providing an additional explanation for the results. The study team observed that workplace changes occurred more frequently in areas where there was active support from the occupational health nurse and the immediate supervisor.

Given the design of this study, it is not possible to identify why some recommendations were implemented and others were not. It is possible that some of the observed changes were not related to the specific recommendations of the ergonomist, but occurred instead because the injured workers were receiving extra attention. Because many of the ergonomic recommendations involved behavior changes, workers might have made some of these changes on their own initiative. It is possible that supervisors may have overstated the changes that actually occurred at the workplace, and the actual number of recommendations implemented may have been smaller.

Other authors have stated that a multidisciplinary team was essential to the success of their ergonomic program. These teams included the employee, supervisor, treating health care provider, ergonomic specialist, insurance providers, and a nurse case manager or occupational health nurse. The role of the nurse was to coordinate meetings, facilitate ergonomic evaluations, and follow up with team members to ensure each team member fulfilled their responsibilities in assisting the injured worker to return to work (Arnetz et al., 2003; Bernacki, Guidera, Schaefer, Lavin, & Tsai, 1999; Bernacki et al., 2000).

This interprofessional team was an integral part of the authors’ study. However, one difference is apparent when this study is compared to the others. In this study, the research nurse did not have official authority to coordinate meetings among the other members and enforce workplace changes.

The success of studies in which the nurse is able to influence change highlights the need for a nurse to have recognized power and authority. This suggests that occupational health nurses are in excellent positions to implement ergonomic programs within their workplaces. With the inherent authority in this role, occupational health nurses are in better positions than external health care professionals to gain managerial support for the programs, better able to enforce and monitor employee adherence, and able to assist when difficulties arise with implementation of recommendations. Consequently, it is feasible to assume that occupational health nurses will be more successful at implementing similar ergonomic programs. It is also likely that occupational health nurses would be interested in learning how to implement ergonomic programs in the workplace. When surveyed, more than 59% of attendees at the 2003 American Occupational Health Conference reported that they would want additional education in repetitive injury recognition and treatment and ergonomics (Mackey, Cole, & Parnell, 2003).

With additional training, the occupational health nurse is in an ideal situation to identify and correct workplace stressors, thereby facilitating the return to work of injured workers. A study by Lincoln, Feuerstein, Shaw,
for job change is likely to reduce more physical stressors than a focused evaluation for one individual. Also, changing work conditions and threats of layoffs, especially within the airline industry, contributed to the difficulty in implementing suggested changes.

While the number of participants from each employer differed and the number of changes that occurred within the companies varied considerably, it is clear that workplace changes occurred as a result of the ergonomic evaluation. The research team observed statistically significant differences among the three employers in the proportion of workers who had administrative and equipment changes made in their jobs. The employers also differed in the proportion of workers who made behavioral changes post-intervention, though this difference was not statistically significant. A larger sample, particularly of university employees, likely would have demonstrated the differences observed among employers. The differences observed among these employers highlights the need to tailor interventions to individuals’ workplaces.

**CONCLUSIONS**

Ergonomic risk factors are obstacles for returning injured workers to work. Interventions to reduce physical stressors in the workplace may facilitate injured workers’ return to work, prevent re-injury, and decrease lost time. Few researchers have evaluated the effectiveness of ergonomic interventions in improving outcomes for symptomatic workers. This area should receive further study.

This study demonstrates that introducing a limited ergonomic evaluation program early in the treatment plan for workers with WMSDs resulted in modification of job stressors. Simple behavior changes were more likely to occur than more complex and expensive administrative or equipment changes. The program was most effective when employees and supervisors were motivated to incorporate the recommendations that arose from the evaluation. The occupational health nurse is in an excellent position to increase the effectiveness of a similar return-to-work program.

**REFERENCES**


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**IN SUMMARY**

**Ergonomic Evaluation**

Part of a Treatment Protocol for Musculoskeletal Injuries

Grayson, D., Dale, A.M., Bohr, P., Wolf, L., & Evanoff, B.


1. An onsite ergonomic evaluation can be used as part of the treatment plan for work-related musculoskeletal disorders resulting in the modification of job stressors.

2. The ergonomic program is most effective when employees and management are motivated to change.

3. The occupational health nurse is in an excellent position to increase the effectiveness of an on-site ergonomic evaluation.

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...and Miller (2002) demonstrates that a brief educational program is an effective method to increase a nurse’s ability to identify a broad range of worksite accommodations for workers with musculoskeletal injuries. In this study, nurse case managers who had participated in a 2-day training program, including tools for identifying and correcting ergonomic hazards in the workplace, offered significantly more recommendations for change and more diverse ergonomic solutions compared to nurses who did not receive the training. In addition, injured workers receiving care from these trained nurses were more likely to have the recommendations implemented. A subsequent article indicates that these same nurses were also able to identify more barriers preventing injured workers from returning to work compared to the control group. Approximately 25% of these barriers were related to the physical work environment including ergonomic risk factors such as workstation design, repetitive tasks, lifting heavy objects, and work pace (Shaw, Feuerstein, Miller, & Wood, 2003).

Both behavior and administrative and equipment changes occurred more frequently for health care and university employees compared to airline ground crew. It is likely this occurred because health care and university employees had more control over their work pace and had much more flexibility in how and when they completed a task. The airline work environment is more structured and there is minimal variation between tasks, making it more difficult for employees to be flexible in how they complete job tasks. The ground crew also encountered more restricted time pressures to perform job tasks and faced a more unpredictable environment in terms of weather conditions, workload, and timing of job tasks. Because this industry uses a more tightly integrated system, it was difficult to make changes in work processes and procedures because of the effects it would have on other elements of the highly interdependent system of passenger flight operations. To be more effective, a system-wide approach...
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