Ergonomic Risk Exposure: Assessment of Safety Shoe Workers

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The purpose of this case study was to assess the ergonomic risk levels of employees in a safety shoe distribution warehouse. Three tasks were evaluated, as they exposed workers to multiple risk factors such as repetition, force, static postures, and awkward postures of the hands, wrists, forearms, shoulders, and back. Exposure assessments were conducted at one warehouse located in eastern Missouri. Analyses were performed using Hand Discomfort Surveys, Body Discomfort Surveys, Strain Index, Hand Activity Level, Rapid Entire Body Assessment, Liberty Mutual Lowering Tool, and the Liberty Mutual Carrying Tool. These assessments were used to estimate risk for upper extremity and lower back musculoskeletal disorders (MSDs) among warehouse workers. Results from this study suggest that the tasks performed in the safety shoe warehouse pose an increased risk for developing MSDs.

Keywords: ergonomics, musculoskeletal disorders, warehouse, shoe distribution

Introduction

Musculoskeletal disorders are a rising problem that is starting to become more and more prevalent within the United States (PRNewswire, 2012). Common MSDs that occur due to work tasks can include back injuries, carpal tunnel syndrome, tennis elbow, trigger finger, and rotator cuff syndrome. Some of the major risk factors that are associated with the development of MSDs are repetitive motions, awkward and static postures, and forceful exertions (UC Berkeley, 2013). In a warehouse setting, like the location in the case study, there are numerous tasks that when performed can increase the risk of developing an MSD (Ergonomics Plus, 2013).
In 2007, according to the Bureau of Labor Statistics, MSDs were accountable for nearly 29% of all work-related injuries that required time away from work and some form of medical attention (Occupational Public, 2009). The average cost of an upper extremity MSD is $8,070 (Sound Ergonomics, 2013). The cost that is estimated annually for work related MSDs is around 20 billion dollars, yet when other indirect cost such as loss of productivity and training are considered, the cost hurdles to a projected 54 billion dollars (Occupational Public, 2009).

Male employees experience almost twice the rate of serious injuries in comparison to female employees (Safe Work, 2012). This is especially true for jobs that require physical labor, such as warehouse work. Hazards should be identified in order to prevent these workplace injuries (St-Vincent, Denis, Gonella, and Trudeau, 2008). Ergonomic analysis tools are applied to identify these hazards. According to the International Ergonomics Association (2011), “Ergonomics is the scientific discipline concerned with the understanding of the interactions among humans and other elements of a system, and the professional that applies theoretical principles, data and methods to design in order to optimize human well-being and overall system performance” (International Ergonomics Association, 2011).

The objective of the study was to assess the ergonomic risk levels of male employees at the safety shoe warehouse and make recommendations to minimize those risks.

Methods

Three warehouse workers from a safety shoe warehouse in eastern Missouri were involved in this study. The three participants were Caucasian males ranging from ages 24 to 55 who voluntarily agreed to participate in the study. Common warehouse operations included loading and unloading shipments, packing shoes for distribution, performing warehouse inventory, wrapping and packaging orders, and lowering and carrying cases of shoes. The three tasks that were analyzed and exhibited the most ergonomic stressors were wrapping and packaging orders, lowering and carrying cases of shoes, and packing shoes for distribution. All three tasks performed in the facility were videotaped and multiple ergonomic analysis tools were used to assess these three tasks.

Hand Discomfort Surveys (Cornell, 1994) and Body Discomfort Surveys (Cornell, 2003) were completed by all three participants. These surveys assessed the amount and frequency of pain or discomfort experienced in specific areas of the hand and body within the past week.
The Strain Index (SI) (Moore and Garg, 1995) and the American Conference of Governmental Industrial Hygienists (ACGIH) Hand Activity Level (HAL) were used to evaluate two of the three tasks that were hand intensive: the wrapping and packaging of orders and packing shoes in boxes for distribution. The SI and ACGIH HAL are used to predict risk of employees developing distal upper extremity MSDs. The evaluators observed the two workers and estimated peak forces based on their examination of the tasks. Data was then entered into the SI and HAL tools in the Job Evaluator Toolbox, available at http://www.ergoweb.com, to evaluate the relative risk of developing MSDs. The SI score was calculated using data only from the workers’ right hands, as those were used most frequently. HAL results were compared against the ACGIH Threshold Limit Value (TLV) and Action Level (AL).

The Rapid Entire Body Assessment (REBA), a postural analysis tool used to predict risk of musculoskeletal injury, was used to evaluate the task of packing shoes for distribution (Hignett and McAtamney, 2000). The collection data form was completed while observing a video and still image of the task being performed. Postural data, such as degrees of flexion/extension and joint deviations of body segments were estimated.

The Liberty Mutual Lowering Tool was used to assess the recommended maximum weight of the load for the lowering task (Snook and Ciriello, 1991). The maximum values of the Lower Range and Vertical Distance of Lower were used because actual measurements exceeded the capabilities of the tool. The Liberty Mutual Carrying Tool was also used to assess the recommended maximum weight of the load for this task. Both Liberty Mutual Tools are used to assess risk of back injury and overexertion injuries in material handling tasks.

**Results**

**Wrapping and Packaging Orders**

The task of wrapping and packaging orders was determined to be the most hand-intensive task of the three that were observed. The employee cut the wrapping paper to the appropriate size, centered the box on the paper, and folded and taped the paper around the box as shown in Figure 1. Scissors and tape dispensers were used to facilitate this task. Boxes typically did not exceed 15 lb. A hand discomfort survey, SI, and ACGIH HAL were used to evaluate this task.
The hand discomfort survey was filled out by the worker and indicated the parts of his hand where he had felt the most discomfort within the last week and whether or not that discomfort had interfered with his job performance. The worker felt the most discomfort in the index, middle and ring fingers and the base of the thumb as reported by the worker in Figure 2.
For the ACGIH HAL, hand activity level was determined by calculating the frequency of hand exertions, which was observed to be “steady motion/exertion; infrequent pauses” and estimating peak finger force to be “very weak.” Figure 3, the resulting graph of the inputs, shows that this task is well-below the TLV Action Limit, indicating that this task most-likely will not cause the development of MSDs and is probably safe for most people. This tool does not take time on task into account when calculating these results, so given that this worker performs this task about six hours per workday, he may actually be at a higher risk for discomfort or injury than indicated by the ACGIH tool.
For the SI tool, the intensity of exertion was estimated to be a “barely noticeable or relaxed effort,” the percent duration of exertion was calculated to be “50% to 79%,” the repetition rate in efforts per minute averaged about 9 to 14, the speed of motion was observed to be normal, and hand/wrist posture was kept “near neutral.” Based on this data, the SI score $= 1 \times 2 \times 1.5 \times 1 \times 1 \times 1 = 3$. An SI score above 7 is considered to be hazardous, so this task is associated with a low risk of developing upper extremity MSD in the hands.

**Lowering and Carrying Boxes**

The lowering and carrying boxes task was not considered hand intensive, but rather potentially stressful on the entire body. This task required the lowering of a 24.25 lb box filled with individual boxes of safety shoes from above the worker’s head, as shown in Figure 4, to the floor for an average of once every 6 seconds.
An entire body discomfort survey (Cornell, 2003) was completed by the worker in order to determine which parts of his body had been experiencing discomfort or pain within the last week, and whether that discomfort had interfered with his ability to perform his job functions. Results in Figure 5 determined that he was experiencing pain several times a day in his neck, upper back, lower back, knee, and feet.
The lowering portion of the task was evaluated using the Liberty Mutual Lowering Tool. The worker who performed this task lowered boxes weighing an average of 24.25 lb, of a width equal to 15.43 in, about once every 6 seconds. Although he was lowering the box from above his head to the ground, the tool assesses a maximum vertical distance of 29.92 in. Because of this limitation, this maximum value was used in the calculations and analysis. The lowering range was observed to be shoulder height to arm reach.

Based on these inputs, the maximum recommended weight of the load for this task is 18 lb meaning the boxes should not weigh more than 18 lb. This is significantly less than the actual weights of the boxes, which are 24.25 lb. This task poses an increased risk of injury to the worker’s lower back.

The carrying part of this task was evaluated using the Liberty Mutual Carrying Tool. Through observation of this task, the vertical distance from the floor to the worker’s hand was determined to be 44 in, the horizontal distance of carrying averaged about 9 ft, and the worker performed this carrying task about once every 12 seconds. The tool calculated the maximum
recommended weight of the load to be 28 lb, which is greater than the actual box weight of 24.25 lb, indicating that the carrying portion of this task presents low risk of injury to the worker.

**Packing Shoes for Distribution**

The task of packing shoes for distribution is a very hand-intensive task that caused workers to assume static and awkward positions. The worker took individual shoeboxes off of a shelf and put them into a larger box for shipping and distribution as shown in Figure 6. While this task can be performed without awkward hand and body postures, the worker who performed this task regularly experienced them due to his work practices.

**Figure 6 – Packing Shoes for Distribution**

A hand discomfort survey (Cornell, 1994) was given to this worker to assess his pain and discomfort within the past week. The results in Figure 7 show he experienced symptoms in his index, middle, and ring fingers several times per day and in the base of his hand one to two times per week.
Since the worker primarily used his middle three fingers to stick into the holes of the shoeboxes to get a good grip to pull them off the shelves, it is clear that there is a direct correlation between those actions and the discomfort he is feeling.

For the ACGIH HAL, the hand activity level was determined by calculating the frequency of hand exertions, which was observed to be “rapid, steady motion/exertion; no regular pauses.” Peak finger force was estimated to be an “obvious effort, but unchanged facial expression.” Figure 8 shows that this task is well above the TLV, indicating that this task is probably hazardous and will most likely cause the development of MSDs in his distal upper extremities.
For the SI tool, the intensity of exertion was estimated to be an “obvious effort; unchanged facial expression,” the percent duration of exertion was calculated to be “50% to 79%,” the efforts per minute averaged about 9 to 14, the speed of motion was observed to be rushed, and hand/wrist posture was kept “near extreme.” Multipliers were as follows: $SI = 6 \times 2 \times 1.5 \times 3 \times 1.5 \times 0.5 = 40.5$.

Based on this data, the final SI score was calculated to be 40.5. An SI score above 7 is considered to be hazardous, so this task is associated with a very high risk of developing upper extremity MSD in the hands and lower arms.

A Rapid Entire Body Assessment (REBA) was used to analyze the most awkward position that the worker maintained while performing this task, as shown in Figure 9. The REBA considered prolonged static posture that this worker held while doing parts of the task, and the angles and deviations of the neck, trunk, legs, arm, and wrist on the right side of the worker’s body. The final REBA score was calculated to be 11, indicating that this task puts workers at a very high risk for development of MSDs and therefore recommends that changes need to be implemented immediately to prevent injury.
The objective of this case study was to identify tasks performed by safety shoe warehouse workers that have the potential to cause discomfort and increase the risk of developing MSDs so that the company can implement changes to prevent injury. Although all three workers experienced some degree of pain and discomfort, only two of the tasks were identified to be potentially hazardous by objective analysis.

The wrapping and packaging orders task was predicted to be the least hazardous to the worker performing the task. Since the HAL was determined to be well below the ACGIH Action Level and the SI was calculated to be 3 (which is significantly less than the hazardous score of 7), this task can be considered low risk. To reduce some of the worker’s pain due to continuous hand use, an increase in frequency and duration of breaks would be beneficial. Job rotation among other employees would decrease the amount of time this worker spends on this particular task and would decrease his exposure to MSD factors (Cal/OSHA, 2007, p.9).
The carrying portion of the lowering and carrying boxes task was determined to be a low risk job. No adjustment needs to be made to the weight of the boxes when carrying them across the warehouse. As long as the worker continues carrying the boxes at elbow height, he should not have difficulty performing this task, and discomfort should be minimal.

The lowering portion of the lowering and carrying boxes task, however, does need significant alterations to be made to the task design. To reduce the worker’s risk of injury, boxes should not be stacked above the head, and the reach distance should be reduced. The weight of the boxes also needs to be significantly reduced from 24.25 lb to about 18 lb. The lighter the load, the less stress it puts on the worker’s body. Changes to this task need to be implemented immediately to prevent further pain and injury to the worker.

The final task of packing shoes for distribution was also deemed hazardous. Since the ACGIH HAL was above the TLV and the SI score was above the hazard level, this task puts the worker at an increased risk for developing upper extremity MSDs. The REBA score of 11 also confirms that the task is very hazardous and needs to be redesigned immediately to protect the worker.

Ergonomic changes to this task need to be implemented as soon as possible. Ways to reduce risk to this worker would include altering the way he physically uses his hands to perform this task, slowing down the speed of work so that it is not as rushed, and providing him with a wheeled-stool to sit on to reduce bending, reaching, and awkward postures when handling shoes on the lower shelves.

Overall, based on the results of this study, it is clear that tasks performed by the workers in this safety shoe warehouse exhibit factors that increase the chances of workers feeling frequent pain and discomfort and potentially developing MSDs. With the proper application of ergonomic controls and adjustments, it will be possible to reduce the risk of work-related MSDs and better protect employees in this work environment.
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