Joint Transportation Research Program

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Applied Ergonomics

Introduction

Ergonomic hazards are a significant concern for construction workers since they can lead to occupational health and safety issues. These hazards can arise when workers are involved in construction activities that exceed their physical capabilities and limitations (Inyang et al., 2012; Seo et al., 2019). In the United States about two million workers suffer from work-related musculoskeletal disorders (WMSDs) annually and about a half million workers lose time from work due to WMSDs (Jeffress, 2000). Common ergonomic risk factors for WMSDs include repetitive motion, excessive force, and awkward posture (Jaffar et al., 2011). As identified by various studies, these risk factors can lead to stress on workers' muscles and tendons during activities like heavy lifting or bending (Jaffar et al., 2011; Omar et al., 2004; Parida & Ray, 2012). The construction industry, along with transportation and warehousing, saw the highest number of occupational deaths in Indiana in 2020, with a total of 57 fatalities (IDOL, 2021).

As a government agency responsible for maintaining transportation infrastructure, the Indiana Department of Transportation (INDOT) plays an active role in both the transportation and construction sectors. Therefore, it is crucial for INDOT to prioritize the health and safety of its workers. Previous research related to transportation safety mainly focused on the issues caused by vehicle drivers instead of the transportation activities. In addition, the applicability of the findings about worker safety in activities from similar industries (e.g., construction industry) to the transportation industry may be limited due to variations in the duration, intensity, and frequency of specific contexts within transportation. Also, the efficacy of previous ergonomic solutions has only been evaluated in laboratory settings, and the practicability of employing them on transportation job sites may differ given complex and ever-changing outdoor conditions.

Findings

- Worker type of top concern.
  - Transportation maintenance workers are the type of transportation workers with the most injuries.
- Injury type of top concern.
  - The highest proportion of reported injuries, 31.58%, were related to the back, followed by leg injuries at 21.05%, shoulder injuries at 15.79%, and arm injuries accounting for 10.53%.
- Activities of top concern.
  - Lifting and pushing/pulling activities were identified as the main concern due to workers' perception of these activities causing back and shoulder injuries, the frequency with which they engage in these activities, and the historical injury cases associated with them.
- Tasks of top concern.
  - Lifting bags of materials and sign stands were identified as the most concerning lifting tasks, based on workers' perceived likelihood of these tasks causing back and shoulder injuries, the frequency of performing these tasks, and the historical injury cases related to them.
  - Shoveling gravels and pulling a dead deer were highlighted as the most concerning pushing/pulling tasks, considering workers' perceived likelihood of these tasks causing back and shoulder injuries, the frequency of performing these tasks, and the historical injury cases associated with them.
- Proposed ergonomic solutions.
  - Lifting bags of materials: use of a back exoskeleton, different weights of bags, and different heights of platforms.
  - Lifting sign stands: use of a shoulder exoskeleton, and different placing approaches, including vertical on the ground, vertical on the waist height, and horizontal on the waist height.
  - Shoveling gravels: use of a back exoskeleton and use of an ergonomic handle.
  - Pulling dead deer: use of a back exoskeleton.
- Evaluation of proposed ergonomic solutions.
  - Lifting bags of materials (please see Section 8.2.1 for details).

- Perceived muscle exertion, muscle contraction, heart rate, and skin conductance are significantly different when wearing and not wearing a back exoskeleton when workers lift 50-pound or 80-pound bags.
- Muscle contraction, heart rate, and skin conductance are significantly different for lifting 31.5-pound, 50-pound, and 80-pound bags when workers wear and do not wear back exoskeleton.
- Muscle contraction is significantly different between workers with less than 5 years of working experience and with more than 5 years of working experience.
- Muscle contraction is significantly different when lifting from less than 20 inches and for more than 20 inches.

- Shoveling gravel (Please see Section 8.2.2 for details).
  - Perceived muscle exertion and muscle contraction are significantly different when shoveling with a regular shovel and shoveling with an ergonomic handle.
- Lifting sign stands (please see Section 8.2.3 for details).
  - Perceived muscle exertion, perceived pressure, and muscle contraction are significantly different when lifting from waist height, compared with lifting from the ground.
  - Perceived usability shows a low usability rate of a shoulder exoskeleton when lifting sign stands.
- Pulling deer (please see Section 8.2.4 for details).
  - No significant differences were found between wearing and not wearing a back exoskeleton when handling a dead deer.

Implementation

Based on the finding described above, the following implementation recommendations are made for the four activities.

- Lifting bags of materials.
  - The utilization of back exoskeletons is recommended when dealing with items of 31.5-pound or more in weight.
  - Lifting 31.5-pound bags is considered to be a safer option than lifting 50- or 80-pound bags.
  - To further minimize the risk of back injuries, the platform height from which the item is being lifted should be at least 20 inches.
  - Controlling the speed at which tasks are being performed can help reduce the likelihood of muscle fatigue.
- Shoveling gravels.
  - Ergonomic handles may lower the risk of straining back muscles, but concurrently increase the risk of arm injuries.
  - Not surprisingly, the complexity associated with wearing shoulder exoskeletons has made them an impractical consideration.
- Lifting sign stands.
  - The height of the platform from which the item is being lifted should be at waist height in order to further reduce the possibility of injuries.
  - A shoulder exoskeleton is not preferred due to its complexity to wear and its limited effectiveness.
- Pulling deer.
  - The proposed solution of a back exoskeleton did not receive scientific support for its effectiveness.

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