Optimizing Workplace and Employee Safety through Ergonomics: Scoping Review

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Abstract

All aspects related to manual material handling if not done properly can result in losses and even accidents. One of the negative impacts of improper manual work handling is the onset of musculoskeletal complaints. To evaluate work postures, especially in production areas that are doing work, ergonomic principles must be applied. This literature research aims to, search for relevant literature related to the application of ergonomics, map the literature so that it can provide an understanding of the importance of ergonomics integration in work safety practices in various industrial sectors. This research uses a scoping review approach to identify, describe, and organize the literature related to optimizing work safety using ergonomic principles. The data collected in this study was gathered by searching scientific literature in online scientific databases using ScienceDirect using keywords and search phrases relevant to the research topic. The final 13 articles obtained were then analyzed, then the articles were classified into 2 topics, namely (1) the use of ergonomics interventions for employee safety and (2) the impact of ergonomics interventions on employee safety. The results of our review found that the application of ergonomics in occupational safety can result in a number of positive impacts on work and organizations such as improved safety, reduction of work-related injuries, increased productivity, reduced fatigue, improved work quality, and worker well-being.

1. Introduction

Occupational safety and ergonomics are two inseparable aspects of creating a safe, efficient and sustainable work environment. Occupational safety is concerned with maintaining workers' well-being and avoiding work-related injuries or health risks, while ergonomics focuses on designing the workplace and its tasks to suit workers' physical and psychological capabilities. Both play an important role in improving workers' productivity, quality of work and quality of life.

All aspects related to manual material handling if not done properly can result in losses and even accidents. One of the negative impacts of improper manual work handling is the onset of musculoskeletal complaints [15]. To evaluate work postures, especially in production areas that are performing work, the principles of ergonomics must be applied. It is important to create a comfortable and safe working atmosphere, as workers are prone to accidents while working. There are still many manual activities that rely heavily on the operator's ability, which can lead to human error in the production process. This can result in losses in terms of cost, time, efficiency, effectiveness, and can negatively affect work

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productivity. Increasing company productivity is greatly influenced by the successful implementation of good management.

Every job will always result in physical fatigue in employees. With a high level of vigilance, the potential negative impacts that may arise can be avoided in the face of various risks that affect the well-being of workers. These risks include the possibility of occupational diseases, work-related diseases, and occupational accidents that have the potential to cause disability or even death. Efforts to anticipate these risks must involve all parties by making appropriate adjustments between workers, work processes, and the work environment.

The importance of understanding the link between ergonomics and occupational safety in the workplace cannot be overlooked. Efforts to optimize work safety by applying ergonomics principles are a crucial step in maintaining a healthy and productive work environment. With the increasing complexity of work tasks, technological changes, and shifts in industry trends, continuous research is needed to address these new challenges. This literature research aims to:

1. Search for relevant literature related to the application of ergonomics.
2. Mapping the literature to provide an understanding of the importance of ergonomics integration in occupational safety practices in various industrial sectors.

This research will hopefully provide valuable insights into how ergonomics can be an effective tool in improving workplace safety. By understanding the linkages between ergonomics and workplace safety, we can develop best practices that will support worker well-being, prevent injuries and increase productivity within various industry sectors.

2. Methods

This study used a scoping review approach to identify, describe and organize the literature related to optimizing work safety using ergonomic principles. The scoping review approach was chosen because it allows a comprehensive exploration of the scope of existing literature in this field without conducting an in-depth critical evaluation like a systematic review.

The data collected in this study was collected by searching scientific literature in online scientific databases using ScienceDirect using keywords and search phrases relevant to the research topic. The keyword used in data collection was "ergonomics" and the use of the word "AND" after the word "safety". Information was extracted from the titles, abstracts and full content of the literature selected for analysis. Data was collected in text form and may include information on ergonomic practices in the work environment, identified ergonomic risk factors, the impact of ergonomics implementation on occupational safety, and proposed ergonomics recommendations or strategies.

The total number of articles found through ScienceDirect was 936. From these results, the articles were filtered using inclusion and exclusion criteria. Inclusion criteria include the type of research article publication, article in the last 5 years, subject area social science, and experiment. The exclusion criteria exclude non-experimental articles. After going through these criteria, 13 relevant articles were obtained. By using inclusion and exclusion criteria, research or literature studies can be more focused on the most relevant sources and in accordance with the research objectives, allowing for more in-depth and accurate analysis.
3. Results and Discussion

The final 13 articles obtained were then analyzed, then the articles were classified into 2 topics, namely (1) the use of ergonomic interventions for employee safety and (2) the impact of ergonomic interventions on employee safety. Table 1 shows the articles analyzed and an overview of the use of ergonomic interventions.

Table 1. Articles used

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<th>No.</th>
<th>Source</th>
<th>Background</th>
<th>Intervention</th>
<th>Result</th>
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<td>1</td>
<td>[1]</td>
<td>Modular construction workers are prone to ergonomic risks, leading to injuries and low productivity. Although assessment methods exist, organizations often ignore them due to insufficient tools and knowledge.</td>
<td>A fuzzy logic-based decision support system that can assist practitioners in assessing the ergonomic performance of work systems automatically and thoroughly.</td>
<td>A case study at a modular construction facility proved the effectiveness of the decision support system. The system generates composite risk scores that reflect physical, environmental and sensory ergonomic risks in the work system. These risk profiles assist practitioners in making tactical and strategic decisions.</td>
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decisions to reduce ergonomic risks. The system serves as an automated ergonomic risk assessment tool that improves occupational health and safety.

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<td><strong>2</strong></td>
<td>[2] Masons suffer from high musculoskeletal disorders in the construction industry. They lack ergonomics training, while the next generation, the apprentices, need training to address ergonomics issues. To address this, the &quot;Safety Voice for Ergonomics&quot; (SAVE) training program was developed.</td>
<td>The SAVE training program consisted of 7 interactive units for masonry and block construction apprentices, which included lessons on ergonomics and communication strategies. The evaluation was conducted over six months using a randomized controlled trial to assess its effectiveness.</td>
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<td><strong>3</strong></td>
<td>[3] The Industry 4.0 revolution is bringing changes in manufacturing and business systems, with a focus on collaborative robots. However, it is necessary to address challenges related to safety aspects and cognitive ergonomics in the design of human-robot assembly systems.</td>
<td>The intervention involved the development of design guidelines based on an analysis of the scientific literature, which summarized findings from relevant studies and provided general technical direction to encourage a variety of solutions. These guidelines were classified based on the four identified interaction variables.</td>
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SAVE training increased interns' "voice of safety" activities and ergonomic practices (P ¼ .049 and P ¼ .028). Interns felt positive about the program and planned to change safety behaviors. In conclusion, SAVE was effective in providing ergonomics and safety communication training for masonry construction workers, potentially improving safety culture and reducing musculoskeletal disorders.

Implementation of the design guidelines improved operator cognitive response and assembly performance. The guidelines support SMEs in adopting human-oriented collaborative assembly systems and assist technicians without knowledge of cognitive risks. These results are relevant for Industry 4.0 in the context of social and economic sustainability, and can be used as a basis for the development of
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<th>4</th>
<th>[9]</th>
<th>This study examined the influence of paramedic equipment bag position on CPR performance and biomechanical load during out-of-hospital resuscitation actions. In the experiment, 12 paramedic teams performed simulated cardiac arrest, with CPR and spinal load evaluations.</th>
<th>Paramedics need guidelines on equipment bag positioning during CPR. This study shows that the initial position of the equipment bag affects CPR quality, physical effort, and biomechanical load of paramedics. Sometimes, suboptimal positioning results in time wastage. In addition, paramedics may assume positions that increase the risk of musculoskeletal disorders and spinal loads that exceed NIOSH thresholds. The study showed that the position of the equipment bag affected paramedics’ CPR quality, physical effort, and biomechanical load. Spinal loads exceeded NIOSH thresholds when lifting equipment bags, and most paramedic positions were categorized as high or very high risk for musculoskeletal disorders according to REBA. Guidelines related to bag positioning can improve CPR quality, patient outcomes, and reduce paramedic injury risk.</th>
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<td>5</td>
<td>[13]</td>
<td>This research attempts to increase road user awareness at railroad crossings by implementing an auxiliary flashing light system on trains. The evaluation includes acceptance, effectiveness, and safety potential with various methods.</td>
<td>The intervention involved installing an auxiliary flashing light system on trains that were tested in real-life situations and driving simulations. The evaluation included data from respondents, driver behavior, acceptance, and safety potential based on previous research and railway crossing safety statistics. The results showed that flashing auxiliary lights are preferable and beneficial. They can reduce driving speed, improve visual scanning, and help detect trains at railroad crossings. The system has the potential to reduce railroad crossing accidents in Europe by 6-30%. Further studies are needed for different configurations of flashing lights and light placement, as well as the influence of weather conditions and different train speeds/distances.</td>
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<td>6</td>
<td>[15]</td>
<td>The issue highlighted is the importance of ergonomic traffic sign design in road safety and traffic flow. This research has three main objectives: 1) Validate the importance of ergonomic traffic sign design; 2) Assess the ability of ergonomics experts to predict sign comprehension by the average driver; 3) Offer improved sign design. The intervention used ergonomic traffic sign designs. Participants from five countries were tested on their understanding of 24 conventional signs and 32 alternative signs that were considered more ergonomic. They were asked to identify the meaning of the signs displayed on a computer and their responses were coded as correct, incorrect, or reversed meaning. Identification response times were also recorded. The results showed that ergonomically designed traffic signs were more easily understood by drivers, with shorter response times in all countries. In conclusion, ergonomic principles are important in sign design, and the views of human factors experts can help improve the design of signs that are difficult to understand or design new signs without the need for large and expensive surveys of users.</td>
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<td>7</td>
<td>[16]</td>
<td>This journal identifies the problem of measuring cognitive load in complex automotive manufacturing tasks, where existing ergonomics methods are not effective enough. The intervention involved measuring eye pupil size and eye blink rate to detect changes in cognitive load during an automotive manufacturing task. Cognitive load was measured through manipulation of the cognitive task (easy and difficult) and variation in physical task duration (short and long), with pupil size and eye blink rate data used as responses. The results showed that pupil size and blink rate increased with higher cognitive task demands. High cognitive load is associated with increased task completion time, higher assessment of mental and time demands, and increased effort expended. Eye metrics can potentially be used to measure cognitive load in occupational ergonomics and dynamic task monitoring.</td>
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<td>8</td>
<td>[25]</td>
<td>The high amount of repetitive manual lifting, such as continuous heavy lifting and working with awkward postures, manual The most frequently picked items should be placed at a distance between 60 and 120 cm. The results show that collectively, these results clearly demonstrate the benefits of picking and replenishing to shelf heights between 60 and</td>
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<td>9</td>
<td>[39]</td>
<td>Lot size affects workload and can result in work-related musculoskeletal disorders (WMSDs).</td>
<td>A new lot-sizing model for MMH planning for manufacturers to minimize total costs. The model integrates several ergonomic aspects to keep the operator's workload at an acceptable level throughout the work process.</td>
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| 10 | [40] | The most common workplace injury claims during pallet wrapping were caused by overexertion and repetitive motion, which accounted for 36% of the claims in this task. | • Techniques in packaging and elevation  
• Using the new pallet wrapping device to reduce the flexing of the lower back when wrapping the bottom of a pallet with a standard load.  
• This new device reduces the height of the humeral torako while wrapping around the highest point of the pallet. | The results show that ergonomic interventions such as the use of this device can reduce postural risks associated with manual material handling tasks.  
The technique used to wrap the pallet containing the matan, as well as the height at which the wrapping is done, affects the posture and muscle requirements of the user. |
<p>| 11 | [46] | Reduced desk area is one of the reasons that force computer users to work | Alternation of upper limb position, between fully supported and | The results showed that the absence of upper limb support during the typing task |</p>
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<th>without forearm support. Unsupported forearms can lead to increased UT muscle fatigue, increasing the potential for lesions, with Trapezius Myalgia (TM) being one of the effects.</th>
<th>unsupported forearm, on Upper Trapezius (UT) activity during a straight desk typing task.</th>
<th>significantly increased UT electrical activity. With full forearm support, the activity was reduced. Women and non-dominant UT showed higher electrical activity, potentially increasing the risk of developing Trapezius Myalgia (TM).</th>
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<td>12</td>
<td>Concerns related to manual handling of bulky items in the industry. Manual oversized sheet metal handling operations can expose workers to risks related to efficiency and occupational safety and health.</td>
<td>Design of a new lifting trolley for sheet metal handling</td>
<td>Pilot studies of trolley lifters show promising results in terms of improvements in cycle time, labor utilization, and work posture compared to traditional handling methods.</td>
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<td>13</td>
<td>The risk of occupational musculoskeletal disorders is higher in the right-sided group.</td>
<td>Job rotation with &lt;1 hour interval</td>
<td>The results showed that job rotation with &lt;1 hour interval reduces the risk of developing UL-WMSDs. Job rotation with &lt;1 hour interval in poultry slaughterhouses is recommended along with further research to verify the effectiveness of rotation with more than two tasks, involving light or non-repetitive tasks.</td>
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### 3.1 Use of Ergonomic Interventions for Employee Safety

In this scoping review method analysis, research results from several journals on ergonomics show that the use of ergonomic interventions can significantly improve employee safety and well-being in various work contexts. For example, research on a fuzzy logic-based decision support system [1] in ergonomic risk assessment proved its effectiveness by generating a composite risk score that covers various ergonomic aspects. Training programs such as Safety Voice for Ergonomics (SAVE) [2] have also proven effective in improving ergonomic practices and safety culture among construction workers. Ergonomic design guidelines [3]
support operator cognitive responses and assembly performance in human-robot collaborative assembly systems environments.

The implementation of guidelines regarding the positioning of paramedic equipment bags [9] can improve the quality of first aid in emergency cases. In addition, auxiliary flashing lights on railroad locomotives [13] show potential to reduce accidents at railroad crossings, while ergonomic design of traffic signs [15] improves driver comprehension in various countries. Finally, measurements of pupil size and blink rate [16] are emerging as useful metrics in measuring occupational cognitive load. These results confirm the crucial role of ergonomics interventions in improving employee well-being and safety across industries and provide rich insights for stakeholders to integrate ergonomics principles in their practices.

3.2 Impact of Ergonomics Interventions on Employee Safety

In order to evaluate the impact of ergonomics interventions on employee safety, this study has explored various journals that reveal significant evidence. The analysis of these journals indicates that ergonomics interventions play a crucial role in improving workplace safety. For example, the application of fuzzy logic-based decision support systems [1] in ergonomic risk assessment can help practitioners identify risks and make tactical and strategic decisions that impact employee safety. Training programs such as Safety Voice for Ergonomics (SAVE) [2] have proven successful in improving ergonomics practices and creating a better safety culture among workers.

Furthermore, ergonomic design guidelines [3] play an important role in improving operator cognitive response and assembly performance, with the potential to avoid hazards and injury risks. In emergency situations such as medical services, guidelines related to the positioning of paramedic equipment [9] can impact the quality of CPR and reduce the risk of paramedic injury. Even in the transportation sector, auxiliary flashing light systems on railway locomotives [13] and ergonomic design of traffic signs [15] provide great benefits in reducing the risk of road accidents. In addition, the results of studies measuring eye pupil size and blink rate [16] can be relevant indicators in measuring cognitive load in higher cognitive tasks. These results suggest that ergonomic interventions that consider monitoring eye metrics, such as pupil size and blink rate, could potentially be used to improve employee safety and comfort.

Then for items that are often picked and placed on shelves designed with a height between 60 - 120 cm [25] can minimize the biomechanical load experienced by selection and replenishment workers. The lot-sizing model proposed in [39] can ease the ergonomic burden on operators. The new device for wrapping pallets tested in [40] can reduce awkward postures (flexion of the lower back at the bottom of the loaded pallet and elevation of the humeral thorax at the top of the loaded pallet), with little increase in muscle demand. The trolley lift design [48] can reduce cycle time (up to 47%) and labor utilization (from two to one). The prototype also improves the safety component of manual handling activities by ensuring minimal physical contact with sharp edges on the sheet metal.

The developed trolley lift enabled better working postures (noticeable reduction in RULA and REBA score ratings in certain task process segments) for transferring sheet metal and eliminated the need to provide manual contact/support to heavy sheet metal during transfer. The work time management [52] of rotating jobs at <1 hour intervals can reduce the risk of developing UL-WMSDs. All these findings illustrate that ergonomics interventions not only improve productivity but also create a safer working environment for employees.

In the context of the impact of ergonomics interventions on employee safety, this research makes an important contribution to understanding how ergonomics principles can play a role in creating safer work environments and safeguarding employee wellbeing across various industry sectors.
3.3 Ergonomics Intervention Research Categorization

Based on the research results that have been presented, we categorize ergonomics interventions into several groups. First, there are Training Interventions such as Safety Voice for Ergonomics (SAVE) [2] and training programs for ergonomic practices and safety culture among construction workers. Second, there are Work Environment change Interventions, including fuzzy logic-based decision support systems [1] in ergonomic risk assessment, ergonomic design guidelines for human-robot collaborative assembly systems environments [3], implementation of guidelines related to paramedic equipment bag positioning [9], auxiliary flashing lights on railway locomotives [13], ergonomic design of traffic signs [15], and measurement of eye pupil size and eye blink rate [16] as metrics of occupational cognitive load. Third, Workstation Design Interventions such as the use of shelves with a height of 60-120 cm for items that are often taken [25]. Fourth, Equipment Design Interventions such as a new device for wrapping pallets [40], designing lifting trolleys for sheet metal handling [48]. Fifth, Work Time Management Interventions such as rotating jobs at intervals of <1 hour [52].

4. Conclusion

Our review found that the use of ergonomics to improve work safety has various positive impacts on work and organizations, such as increasing safety levels, reducing the incidence of work injuries, increasing productivity, reducing fatigue levels, improving the quality of work, and worker well-being. However, some corrective actions warrant further review.

5. Acknowledgement

Not applicable.

6. References


