

Impact of a passive exoskeleton on human performance

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SUMMARY

This study evaluated the use of passive upper-limb exoskeletons in a bicycle assembly line to improve employee productivity and ergonomics. Results showed that exoskeletons improved posture and reduced back pain for tasks requiring work above shoulder height, but were less effective for tasks involving bending or varied postures. The research concluded that exoskeletons are beneficial for specific tasks but need careful selection based on the work environment, with further testing recommended for longer durations.

KEYWORDS

Exoskeleton, Physical Workload, Human Performance

Context

Within a funded project, which aims to investigate how robots and assistive technology can be used to provide inclusive and sustainable workplaces for all workers, one of the research areas focusses on physical enhancements (like wearable robots) in a real world context. In this research area a case study was conducted in a final assembly line of bicycles in a Bicycle company in Holland. The scope of the research in this case study was to integrate exoskeletons into manual production lines, improving physical ergonomics resulting in increased productivity (De Looze et al., 2016).

Actions

To achieve the aim of the research of the case study - evaluate the impact of passive industrial upper-limb exoskeletons on employees' productivity - data is collected, analysed and evaluated using different methods. To obtain a comprehensive description of the workplace within the assembly line, four evaluation methods were used, starting with a task analysis, followed by the Rapid Upper Limb Assessment (RULA) and the Key Indicator Method (KIM), an assessment of the level of automation and, finally, recording of external circumstances. For the description of the process and the operator within the assembly line various questionnaires and interviews were conducted.

Guided by the research plan, the bicycle company was visited several times to understand the assembly process, select the most suitable stations within the assembly line to test the exoskeleton and conduct a pilot test. The three stations chosen were those with the most tasks requiring work above shoulder height or a task with a longer duration of work above shoulder height.

The final research was conducted on several days, during which videos were made of the participants working on the stations, both with and without wearing the exoskeleton. Using these videos and the results of the task analysis, the postures were analysed using the RULA and the KIM. The RULA is a screening tool that assesses biomechanical and postural loading on the whole body with particular attention to the neck, trunk and upper limbs. The KIM is a survey method

developed for use of assessing and designing physical workloads with respect to manual Lifting, Holding and Carrying of loads ≥ 3 kg. In addition to video recording, interviews were conducted and questionnaires administered both before and after wearing the exoskeleton. Finally, all the data was analysed.

Outcomes

The evaluation of the exoskeleton demonstrated a positive impact, particularly in terms of improved RULA scores for workplaces where employees need to work above shoulder height. In addition, there were positive experiences among participants wearing the exoskeleton (“My body is fixed”, “I feel I work in a better posture” and “I experience less backpain during the task”) and greater ease in specific tasks (“Lifting the motor is easier”).

However, workplaces involving more varied tasks and postures, particularly those requiring bending, were found to be less suitable for exoskeleton use. Participants reported experiencing less freedom of movement.

Discussion

The study provides valuable insights into the impact of passive exoskeletons on the physical workload. While positive experiences were noted, it also highlighted the need for a nuanced approach, considering task complexity, variety and workplace conditions.

For the chosen workplaces within the bicycle company, using a passive exoskeleton is not the best solution due to the variety of tasks (not only above shoulder height, but also involving a lot of bending). Furthermore, other ergonomic issues within these assembly workplaces need to be addressed first.

Conclusion

In conclusion, we can affirm that the research setup and chosen methods worked well. However, the careful selection of the workplace (or task) for the application or introduction of a passive exoskeleton is essential. We recommend testing for a longer period in the field, specifically at workstations where employees have to work for extended periods at or above shoulder height. This would allow for a better evaluation of the impact of passive industrial upper-limb exoskeletons on employees' productivity.

Reference

De Looze, M. P., Krause, F., & O’Sullivan, L. W. (2016). The Potential and Acceptance of Exoskeletons in Industry. *Biosystems & Biorobotics*, 195–199. https://doi.org/10.1007/978-3-319-46532-6_32