ESO-EAWS® Certification project

HOW and **WHEN** can exoskeletons reduce the biomechanical load of workers? The ESO-EAWS® projects offer relevant recommendations.

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ABSTRACT

The use of exoskeletons has become of interest in the industrial manufacturing sector. From managers to users and unions, the open challenge was to quantify the reduction of biomechanical load, still not enough for the right implementation of exoskeletons on field. In this paper, Fondazione Ergo aims to highlight recommendations to be considered in the introduction of industrial exoskeletons and the goals of the ESO-EAWS® project.

Premise

Ergo Foundation is a Non-for-Profit independent body, participated by the manufacturing industry, the social partners (trade unions), and academic institutions. The ESO-EAWS® project was conducted without any conflict of interest to improve the definition of the conditions in which the use of an exoskeleton can bring a benefit to the company and the workers.

The ESO-EAWS® scientific research projects were born from the collaboration of Fondazione Ergo with the Alma Mater Studiorum University of Bologna, the Laboratory for Engineering of Neuromuscular System (LISiN) of the Polytechnic of Turin, and the EAWS® International Platform (https://www.eaws.it/practice-areas/) to face an important **open issue** in the field of industrial manufacturing: *to understand where and measure how the use of exoskeletal* *systems can effectively reduce the biomechanical load of industrial workers, assisting them in their postures and movements*.

RECOMMENDATIONS

In tackling an ergonomic problem generated by a manual work task that causes the worker to have an excess biomechanical load, **good industrial engineering practices recommend a detailed and accurate analysis of the planned work method** in a given workstation (work cycle) and the ergonomic evaluation of the repetition of the same cycle during the work shift. Common sense and the rules in place today regarding the control of the risk due to biomechanical overload, which can cause occupational diseases on the musculoskeletal system, recommend as a first best provision redesigning the working method, to eliminate those movements/actions that are more critical and tiring (technical solutions that usually require investments and need to be approved). Secondly, there are organizational solutions, which do not eliminate the problem at its root, but lower the health risks for the workers (e.g. balancing assembly lines and job rotation). In cases where it is not possible to adopt technical solutions due to cost or feasibility problems and the organizational solutions are not practicable or convenient, an appropriate exoskeleton can be considered, based on technical and economic factors and good acceptability by the workers. [1]

PROJECT OBJECTIVES

The research projects called ESO-EAWS® were created to provide companies with a reference to quantitatively evaluate the biomechanical load reduction effect brought about by the correct use of a specific exoskeleton. In doing this, the ESO-EAWS® project implicitly defines the limits of use of the exoskeleton, both technically (instructions for correct use) and economically (if and how much the biomechanical load is reduced).

The results of the ESO-EAWS® project allow us to relate the economic investment in wearable technologies to support manual work in an industrial context with the benefits of reducing the fatigue level of the operator and, consequently, improving the quality of his work, benefits preliminarily tested in some studies [2][3].

The first question we wanted to answer with our study was **WHEN** the adoption of exoskeletons is recommended. To answer this question, it is certainly useful to know the extent of the reduction of the biomechanical load to which a worker is exposed due to the assigned work cycle. Concerning the considerations mentioned in the (2019) European Agency for Safety and Health at Work's publication "The impact of using exoskeletons on occupational safety and health":

"*The most important concern is that caution should be exercised when using technology so close to the human body. Technical and organizational measures should be taken into account when designing workplaces before employees are equipped with exoskeletons. In general, using exoskeletons to improve the ergonomic design of workplaces should always be the last resort*."

"*It should be mentioned that the use of exoskeletons to improve the ergonomic design in* *stationary workplaces cannot be recommended, but there are also a vast number of non-stationary or mobile workplaces in which ergonomic measures are not possible. In this context, exoskeletons may offer a promising approach to reduce WRMSDs in the future*."

The **main objective** of the study was to **measure the quantitative impact** of a passive upper limb supporting exoskeleton **on the score** representative of the risk level due to **biomechanical load.** The ergonomic measurement system used in the project is EAWS® (Ergonomic Assessment Work-Sheet), thanks to its comprehensive structure, which considers body postures, action forces, manual material handling of loads, and highly repetitive motions of the upper limbs.

*"The study is **a virtuous example of independent evaluation, carried out with rigorous methods,** and approved by the Scientific Committee of the EAWS® International Platform. More generally, it provides a further demonstration of the effectiveness of a new generation of assistive devices for manual work* "says Prof. Violante (University of Bologna).

THE ADOPTED PROTOCOL

The experimental protocol, approved by the bioethics committee of the University of Bologna, was defined by a team of experts including Prof. Francesco Saverio Violante (President of the Board of Experts of Fondazione Ergo) and Prof. Marco Gazzoni, head of the Laboratory of Engineering of the Neuromuscular System (LISiN) of the Polytechnic of Turin.

Twelve subjects (20-30 years, mean frequencies of gender, height, weight) were recruited for the study and provided electromyographic upper body data recorded in 12 different postures (8 statics and 4 dynamics). Electromyographic measurements were performed on the muscles mainly involved in maintaining the assessed postures (trapezius, anterior, medial, and posterior deltoid, biceps, triceps) using surface electrodes.

The use of an optoelectronic movement analysis system was used to check for the correct execution of the movements.

Once the first phase of electromyographic measurements was completed, the percentages of muscle activity reduction were used in a calculation model to determine the new EAWS® scores for the Body Postures (Section 1) and Repetitive Movements of the Upper Limbs (Section 4) sections. Counterbalancing scores were also assessed in Section 0 of EAWS® expressing the level of discomfort and bulk caused by wearing an exoskeleton. This second phase was led by an EAWS® team of expert instructors of Fondazione Ergo, supported by the Scientific Committee of the EAWS® Platform.

Important note

The results published by the study concern the reduction of EAWS® scores, which represent the level of biomechanical load. The study does not add any element concerning the assessment of the risk associated with the biomechanical load compared to what the EAWS® assessment system already offers. On the contrary, it introduces a further validation element, which will have to be demonstrated by subsequent longitudinal studies, concerning the risk reduction associated with the adoption of the exoskeleton.

The reduction of the EAWS® score is an indication of an improvement in working conditions. Concerning this study (passive shoulder support), such an improvement is limited to specific situations in which shoulder awkward postures are relevant in intensity and duration. This study does not recommend the use of the exoskeleton but aims to define the correct conditions of use and measure its impact on the reduction of the biomechanical load.

To download the study reports, please use the following link: https://www.eaws.it/exoskeleton-certification/

References

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[3] Pauline Maurice, Jernej Camernik, Dasa Gorjan, Benjamin Schirrmeister, Jonas Bornmann, et al.. Objective and Subjective Effects of a Passive Exoskeleton on Overhead Work. IEEE Transactions on Neural Systems and Rehabilitation Engineering, IEEE Institute of Electrical and Electronics Engineers, 2020, 28 (1), pp.152-164. 10.1109/TNSRE.2019.2945368.hal-02301922v2