The Potential and Acceptance of Exoskeletons in Industry

Michiel P. de Looze, Frank Krause and Leonard W. O'Sullivan

Abstract Worldwide, a significant interest in wearable robots or exoskeletons does exist, also from an industrial background. This paper provides an overview of assistive exoskeletons that have specifically been developed for industrial purposes. It discusses their potential in increasing performance and flexibility on one hand and in reducing the mechanical loads on workers involved in manual work on the other. From this it is concluded that exoskeletons have the potential to increase performance under specific conditions and to reduce physical loads significantly. However, several technical issues hinder mainstay practical use of exoskeletons in industry until now. One main issue concerns the human-machine interaction which stands in the way of acceptance. This issue and its linkage to ethics and standardization will be discussed during the conference.

1 Introduction

Despite the on-going trend in automation in industry, many workers are still exposed to physical workloads due to material handling (over 30 % of the work population in the EU), repetitive movements (63 %), and awkward body postures (46 %) [1]. To reduce the health risk involved, one approach might be the use exoskeletons.

M.P. de Looze (✉) · F. Krause
TNO, Leiden, The Netherlands
e-mail: michiel.delooze@tno.nl

F. Krause
e-mail: frank.krause@tno.nl

M.P. de Looze
VU University, Amsterdam, The Netherlands

L.W. O'Sullivan
University of Limerick, Limerick, Ireland
e-mail: leonard.osullivan@ul.ie

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An exoskeleton can be defined as a wearable, external mechanical structure that enhances the power of a person. The main application area of exoskeletons has been for medical/rehabilitation purposes where the devices are aimed to support physically weak, injured, or disabled people [2].

In this paper, we determined the potential of exoskeletons to be useful in industry settings from the perspectives of industrial performance and workers health, and address the shortcomings as it comes to acceptance. To that purpose, we performed a stakeholder analysis and a literature review. The issue of acceptance in relation to ethics and standardization will be discussed during the conference on the basis of field tests in the automotive industry with the so-called RoboMate exoskeleton.

2 Methods

2.1 Stakeholder Analysis

Eight experts in the field of manufacturing industry who could elaborate on the business and social needs and the value of human work in production environments were approached and consulted by interview. They were interviewed about the main general trends in manufacturing industry, about the current and future developments in the value of human work within these trends, and about the needs in relation to any type of exoskeleton to be potentially used on the manufacturing shop floors from the business perspective.

2.2 Literature Review

A literature review was performed by an electronic literature search using the Scopus search engine. We focused on exoskeletons developed for use in occupational fields to support shop floor workers perform physically demanding activities. Papers considering other applications, e.g. rehabilitation, medical, tele-operations, military, and virtual reality, were excluded. We included all types of exoskeletons, i.e. passive and active, anthropomorphic or not, and lower body, upper body and full-body exoskeletons. Single-joint exoskeletons covering the hand and wrist only, were excluded.

2.3 Acceptance

The issue of acceptance will be discussed based on the outcome of the field tests with the RoboMate exoskeleton, which has been developed recently and will be tested in the automotive industry during summer time in 2016.

3 Results

3.1 Stakeholder-Analysis Results

The following trends in manual work, of relevance for the potential use of exoskeletons in manufacturing, were stressed by the stake-holders.

- Due to mechanization and automation, manual work on the shop floor decreases, while more people are involved in the pre-production planning, programming, engineering
- Due to increased needs for flexibility, more human workers are required on the shop floor, particularly in highly-automated environments
- Due to the ageing of the work force, technology-based support is required to keep older workers productive and safe
- Due to the shortage on the labour market, one should increase the attractiveness of factory work for new employees.
- Due to prevalence of injury (back, shoulder, arms), technology-based support is required to reduce the physical loads on workers.

Main business and social needs of relevance for the application of exoskeletons put forward in the interviews:

- Need to increase the flexibility of production
- Need to increase the flexibility of workers
- Need to increase the productivity of manual work
- Need to increase the quality of manual work
- Need to reduce the physical load and the risks of injury.

The stakeholders indicate that an exoskeleton could be most useful in the following situations:

- Flexible production cannot be achieved through automation because of frequent changes of activities, product types and order sizes,
- Weights of parts are just too large to be safely handled by a person while task execution is not on a specific location (thus, local cranes are not an option),
- Preventions of manual handling injuries is required.

Finally, it was stressed that the main benefit of the application of an exoskeleton above any type of robot system (classical robots, full-automation systems or humanoid robots), would be that, specifically in dynamic environments, one will fully profit from the human's creativity and flexibility, while he is the one in charge, and there is thus no need for robot programming or teaching of robots.

3.2 Literature Review Results

The search resulted in 40 papers in which an exoskeleton with an industrial purpose was described. In these papers a total of 26 different industrial exoskeletons were described These were broken down as 20 upper body, 4 full body, and 2 lower body exoskeletons, with 19 being active (among others [3–8]) and 7 passive (among others [9–13]).

These exoskeletons were most frequently aimed to give support in stooped working postures, static holding of a load, and dynamic lifting (and lowering) of a weight. Some studies also mentioned carrying as an activity to be supported. Finally, some job specific activities were mentioned, i.e. patient lifting and transfer (for three different exoskeletons), construction work, agricultural and overhead carpentry work.

For 13 out of the 26 industrial exoskeletons, some evaluations of the physical load reductions were performed.

Generally, positive effects, either tested statistically or not, have been reported for the physiological (EMG) and biomechanical parameters, both for the passive and the active exoskeletons. For the passive exoskeletons, 10 to 40 % reductions in back muscle activity during dynamic lifting and static holding have been reported. For the active exoskeletons, muscle activity reductions up to 80 % have been reported.

4 Discussion and Conclusions

Exoskeletons may be specifically useful where workers have to handle weights which are above health threshold limits, where materials handling takes place at various spots (worker needs to be mobile), and where the production tasks are too difficult to fully automate.

Exoskeletons have the potential to considerably reduce the underlying factors associated with work-related musculoskeletal injury.

At this point however, several issues hinder acceptance in industry. One main issues, the human-machine interaction, will be discussed in detail on the basis of the outcome of fieldlab testing of the RoboMate exoskeleton, as well as its implications for standardization.

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