Editorial

Sascha Wischniewski*

Federal Institute for Occupational Safety and Heath (BAuA),
Friedrich-Henkel-Weg 1-25, 44149 Dortmund, Germany
Email: wischniewski.sascha@baua.bund.de
*Corresponding author

John Rasmussen

Department of Materials and Production,
Aalborg University,
Pontoppidanstraede 103, DK-9220 Aalborg East, Denmark
Email: jr@mp.aau.dk

Exoskeletons are breaking through as ergonomics safety equipment in workplaces and as rehabilitative or assistive devices. Large industry branches, such as warehouses, logistics, food production, assembly line work in general, facility management, and construction, are embracing mainly passive exoskeletons as safety equipment, while active exoskeletons bring the hope of enhanced mobility to the elderly or disabled.

This development requires a research foundation in which translational topics of ergonomics, human factors, biomechanics, and human models, in general, play an important role. The human and the exoskeleton form a united biomechanical system, whose elements cannot be understood in separation. In many cases, the effect of an exoskeleton intervention is difficult or impossible to measure, and accurate modelling of the combined system is the only way to assess the effects before long-term and possibly undesirable consequences appear. Similarly, modelling and simulation of the interaction between the human and the exoskeleton may be the best way to drive the design of mechanics and control systems forward. This special issue aims to compile research on humans and exoskeletons in modelling and practice.

We invited contributions from leading scientists in the field, including substantially extended versions of selected papers presented at the 21st Triennial Congress of the International Ergonomics Association (IEA2021), for review and potential publication.

The topics covered in this special issue range from repeatability of a measurement method for human motion capturing, to the comparison of two rigid-body methods to simulate the human-exoskeleton interface, as well as an evaluation method for the ergonomic effects of introducing an exoskeleton into a production context. Other topics include the analysis of design-relevant body parameters for exoskeletons of men and women via archetypal analysis, and an examination of how shoulder muscle forces and biomechanical loads in the glenohumeral and L4-L5 joints changed with different support torque and angle settings of an exoskeleton.

Bostelman et al. present the feasibility and repeatability of a measurement method that enables synchronous tracking of human and exoskeleton kinematics using a set of lower-limb human motion capturing test artefacts and exoskeleton motion capturing plates. To apply the measurement of the test artefacts' rigid body position and orientation, they implemented two potential metrics, based on the exoskeleton-human alignment offset and the stability of the exoskeleton frame.

Chander et al. investigate different strategies to simulate the force exchange over the human-exoskeleton interface, while accounting for the effects of unavoidable, small misalignments in an active lower limb exoskeleton in stair ascent.

Garcia Rivera et al. present a general method for evaluating the ergonomic effects of introducing an exoskeleton into a production context using digital human modelling simulation tools combined with a modified existing ergonomic assessment framework. They adapt the Assembly Specific Force Atlas tool to evaluate exoskeletons by increasing the risk level threshold proportionally to the amount of torque that the exoskeleton reduces in the glenohumeral joint.

Qiu et al. conduct several auditory prompt experiments to determine the most adaptive movement feedforward method for patients with spinal cord injury to improve transparency for a lower-limb exoskeleton for standing and walking assistance in daily life. This work addresses the important issue of lack of proprioception in lower limbs in spinal cord injury patients wearing a lower-limb exoskeleton, which necessitates feedforward information from the human-exoskeleton system for walking safety.

Riemer and Wischniewski present exoskeleton design-relevant body parameters of men and women as an input to suitable adjustment ranges for shoulder and back exoskeletons. Therefore, they identified relevant body parameters for back, and shoulder exoskeletons and calculated the upper and lower bounds for males and females by applying the archetypal analysis on a large anthropometric dataset from Germany.

Seiferheld et al. examine how shoulder muscle forces and biomechanical loads in the glenohumeral and L4-L5 joints changed with different support torque and angle settings of an exoskeleton during an overhead manual material handling task. With kinematic data, they drive a detailed human-exoskeleton model based on inverse dynamics and investigate the change of compression and anteroposterior shear forces, glenohumeral contact forces and shoulder flexor muscle forces.

The work presented in this special issue illustrates the many facets of exoskeleton development and deployment – an ongoing challenge for science and practice.