



Federal Institute for Occupational
Safety and Health

Review of Exoskeletons

Speaker: Markus Peters



Overview

- **Introduction**
- **Exoskeletons**
- **Evaluation of exoskeletons**
- **Fields of applications**
- **Challenges for OSH stakeholders**

Introduction

WRMSD in Europe

- 40% lower back pain/ shoulder complains
- 63% repetitive tasks
- 46% hazardous body postures

Eurofound (2012). *Fifth European Working Conditions Survey*

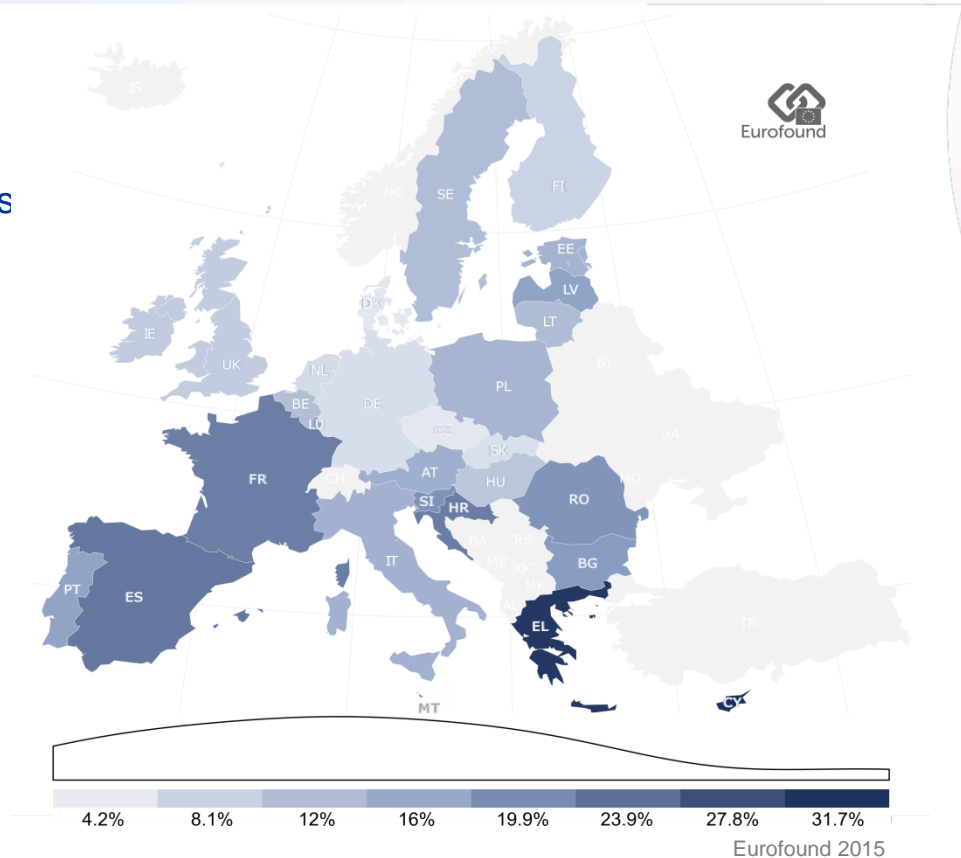
Costs

- 2% of the gross domestic product

Bevan, 2015



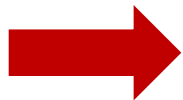
**Not only health related
Central economic relevance**



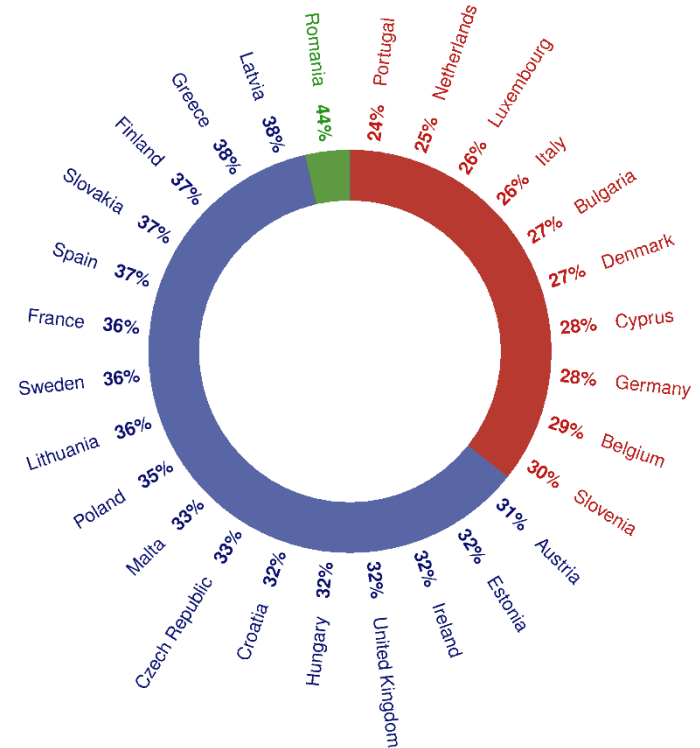
Introduction

WRMSD in Europe

- **Manual Material Handling (MMH)**
 - Lifting, lowering, holding carrying
 - Overhead work
 - Twisting and bending
 - Painful/ tiring positions
- **Heavy loads**
 - Exceeding 10 kg for woman and 20 kg for men



**Improve working conditions
Developing new tools**



Tools to improve working conditions in Europe?

- A device to supports the musculoskeletal system
- Mobile and flexible in application
- Reduce the risk for work related disorders

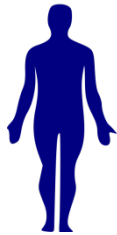


Exoskeletons for better conditions?

Exoskeletons

- **“Exoskeletons are external devices that are worn for an intended purpose such as rehabilitation or replacement for lost physical functions like walking” (Reid et al., 2017)**
- **Exoskeletons are assistance systems worn on the body that act mechanically on the body. (in accordance to Liedtke & Glitsch 2018)**
- **A personal assistance robot that physically assists a user in performing tasks by enhancing the user's physical capabilities. (in accordance to ISO 13482:2014)**

What is an exoskeleton?



Functionality



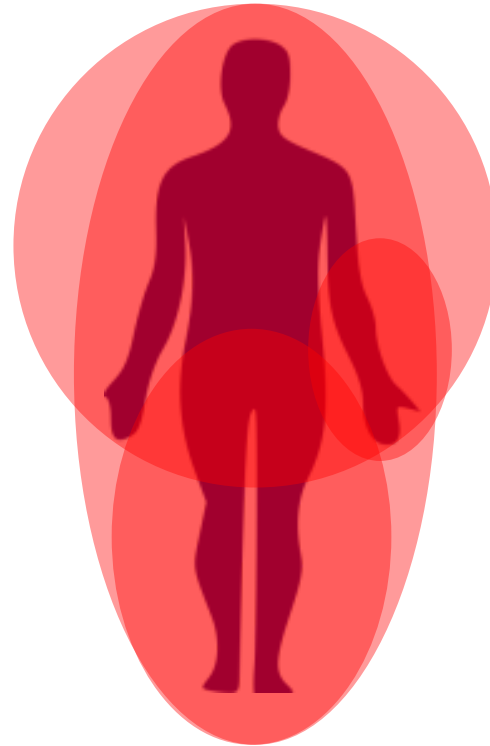
Design



Application

Funktionalität

- Upper-Body exoskeletons
- Lower-Body exoskeletons
- Full-Body exoskeletons
- Singel-Joint exoskeletons



Exoskeletons

Design

- Passive exoskeletons
- Active exoskeletons
- Hybrid exoskeletons





Raytheon Bionics


Source: <https://www.globenomics.com/industry-research/robotics/robotic-exoskeleton/>
Bionic_4-1.jpg

<http://osha.europa.eu>

Application

- **Technical device**
 - Machinery Directive (2006/42/EC)
 - Bound to workplaces
 - No personal measure

- **Personal protective device**
 - Regulation 89/686/EEC
 - PPE 2016/425
 - Hygienic standards
 - Personal measure

- **Medical device**
 - Regulation 93/42/EEC
 - Reintegration purposes

The definition of an exoskeleton is strongly related to its type as well as its intended use.

The effects of exoskeletons

Physiological aspects

User acceptance

Biomechanical aspects

Evaluation of exoskeletons

Physiological aspects

- **The weight of an exoskeleton**
 - Oxygen consumption
 - Heart rate
 - Blood pressure
- **Pressure points**
- **Skin irritations**

Currently no evidence on the physiological effects of exoskeleton.

User acceptance

- Stigmatisation
- Discomfort
- Limited user acceptance among older users

User acceptance is positive

Gilotta et al., 2018

User acceptance decreases over time

Hensel et al., 2018

Evaluation of exoskeletons

Biomechanical aspects

- **Exoskeletons can reduce the physical stress in local body areas**
 - Shoulder joint
 - Lower spine

Abdoli-E et al., 2006; Graham et al., 2009; Bosch et al., 2016;
De Looze et al., 2016; Theurel et al., 2018; Weston et al., 2018

- **Increased stress in other body areas**
- **Changed movement pattern**

Exoskeletons show relieving effects on the musculoskeletal system but influences other parameters

At present, there is little scientific evidence on exoskeletons in ergonomics and work related science.

Fields of applications

30% of working tasks are still associated with MMH

Eurofound (2012). *Fifth European Working Conditions Survey*

- All workplaces with tiring and painful body postures
- Repetitive tasks and overhead work
- Workplaces where ergonomic measures can not be implemented
 - Furniture delivery
 - Emergency service



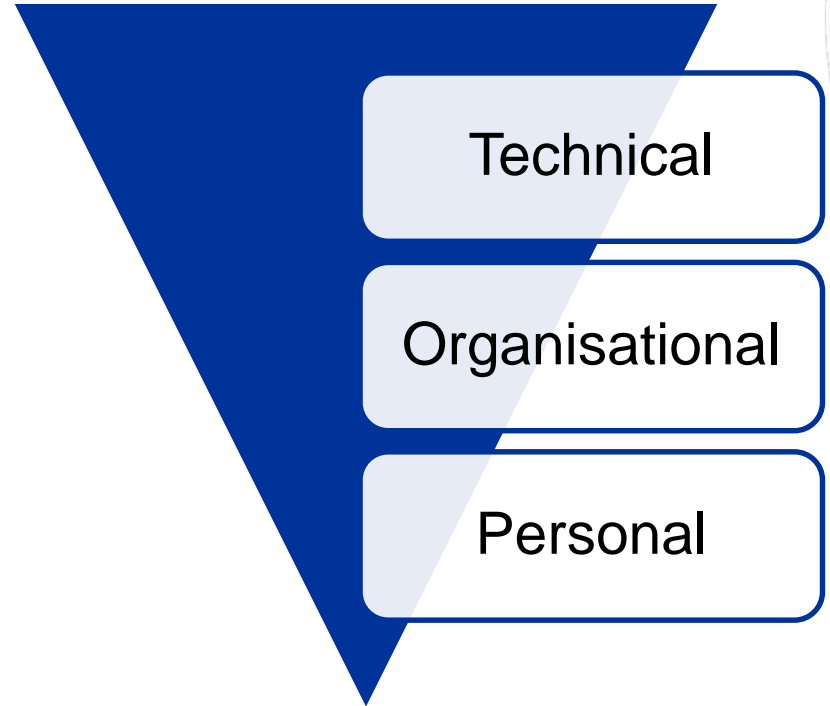
The use of an exoskeleton should always be the last option to improve ergonomic working conditions.

Challenges for OSH stakeholders

Principles of a human centered design



As long as technical or organisational measures are still possible, the use of exoskeletons to reduce the risk of work places can not be recommended.



Summary

- 1. We need better working conditions in Europe. Exoskeletons provide various application possibilities.**
- 2. The definition of an exoskeleton is strongly related to its type as well as its intended use.**
- 3. Currently there is only little evidence.**
- 4. Stick to the principles of a human centered design.**

Thank you for your attention

Markus Peters
Dr. Sascha Wischniewski

Unit „Human Factors, Ergonomie“

Friedrich-Henkel-Weg 1-25
44149 Dortmund
+49 (0) 231 9071 2534
peters.markus@baua.bund.de
www.baua.de