



Occupational exoskeletons

May 2022

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- 3) Differences in exoskeleton design
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Ergonomical situation

- **Two third** of construction workers report on working positions in **comprised working posture** (hunched, kneeling, overhead) (BAuA, 2014)
- **82%** of construction workers report on **muskuloskeletal problems** or pain in the last 12 months – **40%** report on more than **4 different muskuloskeletal problems** in the last 12 months (BAuA, 2014)
- **35-45%** of construction workers complain about **upper limb pain** (Park H.J. and Jeong B.Y., 2021)
- MSDs common among construction workers. Over **40%** of **construction workers over 50** report **persistent pain** or physical problems (Wang et al., 2017)
- **Elderly construction workers** are more exposed to overload than their youger peers, **workload has to be adjusted** (Jebens et. al, 2015)



Body parts under stress

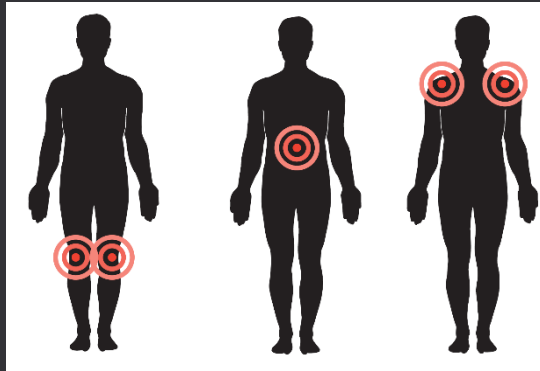
Exemplary
activities

load handling

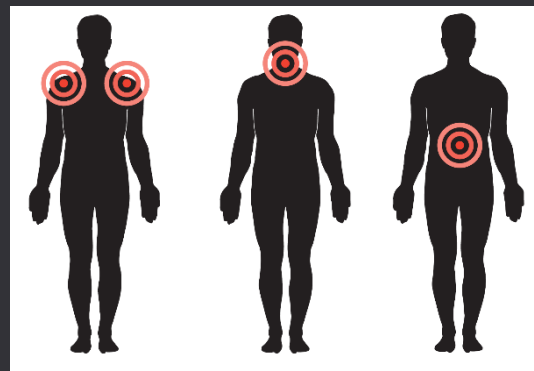
activities above shoulder

microassembly

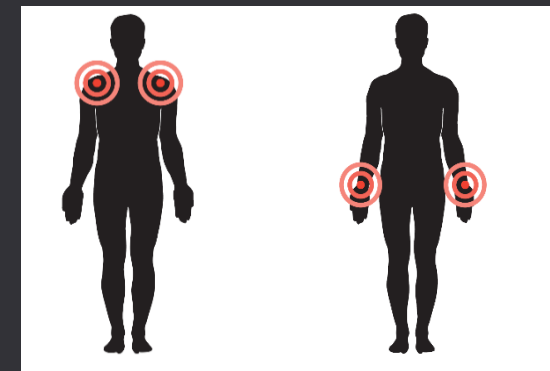
Body areas
under load



- Lower back
- Shoulder
- Hip and Knees



- Neck
- Shoulder
- Upper and lower back



- Neck
- Shoulder
- Wrist

What are exoskeletons?

Definition

Electromechanical system, that can be worn by a person [...] in order to enhance the power of the muscles by a direct transfer of mechanical energy from the device to the human (Rukina et al., 2016)

Distinctions:

- By supported body areas
- By morphology
- By differences in actuating elements (actuators)



upper limb
exoskeleton
(rigid)



lower back
exoskeleton
(semi-soft)

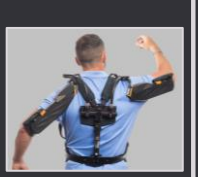
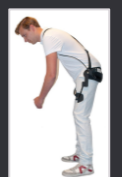
Exoskeleton myth #01 debunked: Superpowers

Full episode here:

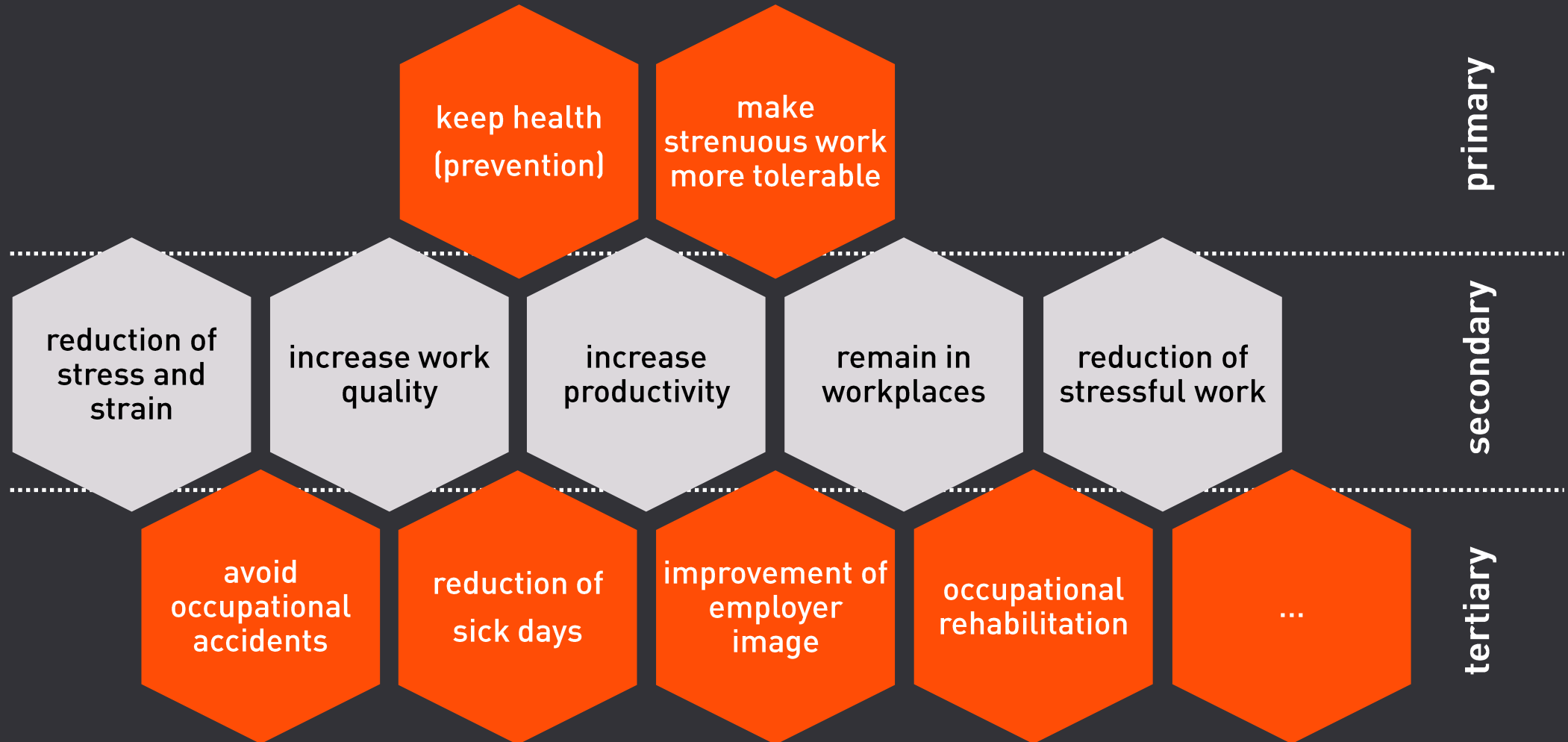
www.exoiq.com



Exoskeletons and their type of support

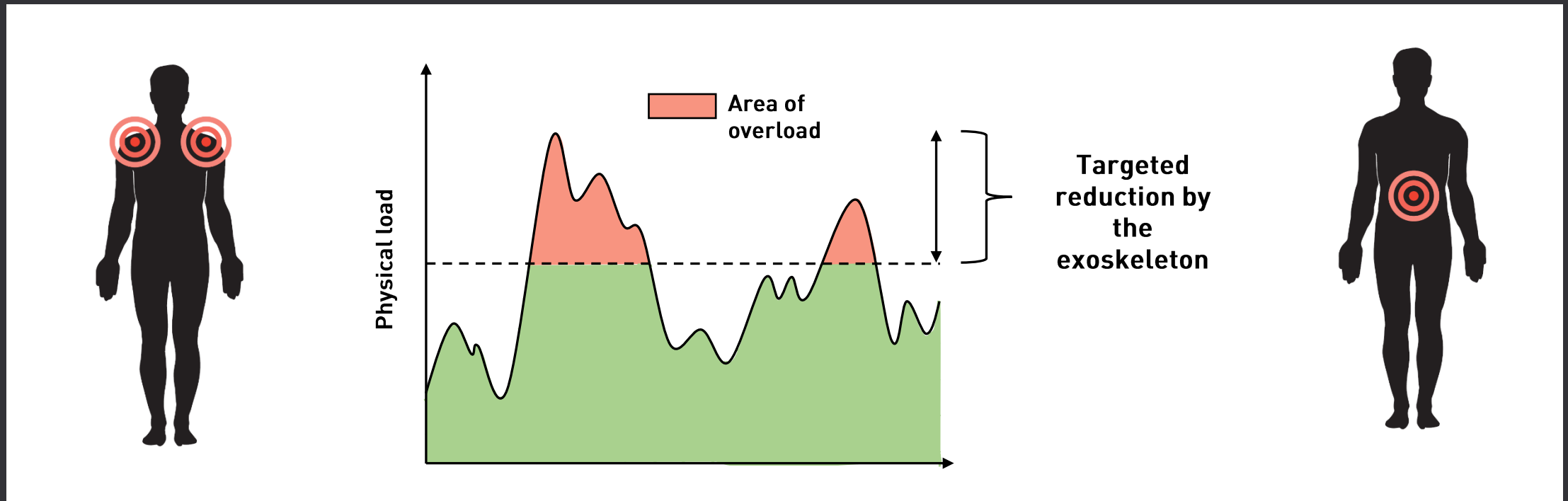
Exoskeleton use cases							
Type of support							
Enable movements							medical use
Allow for movements							
Assist movements							occupational use
Stabilize movements							
Artificial movements							

Exoskeletons for prevention of MSD

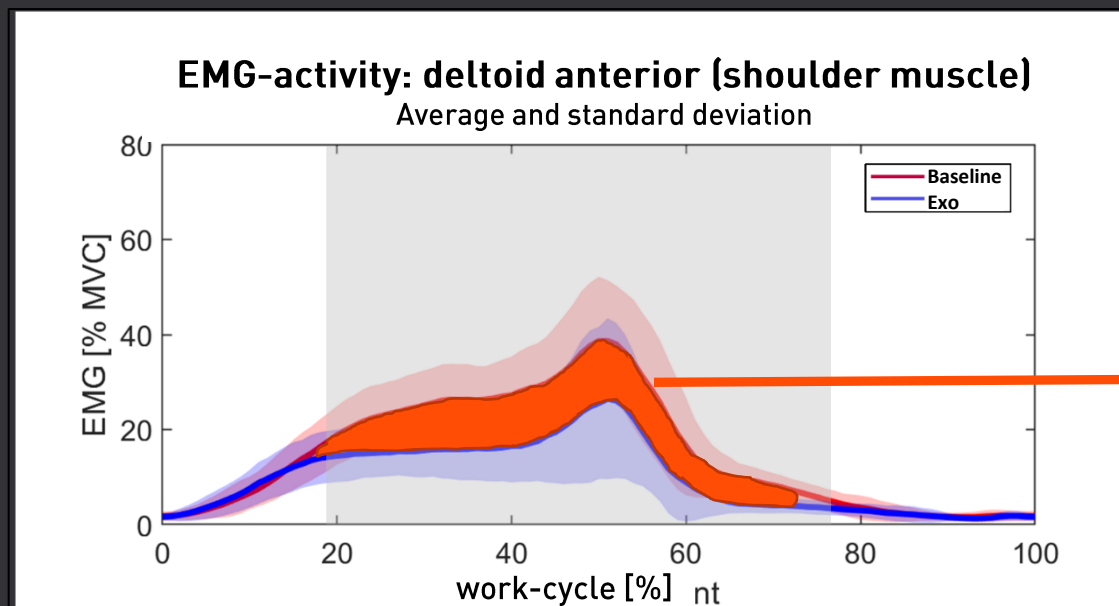
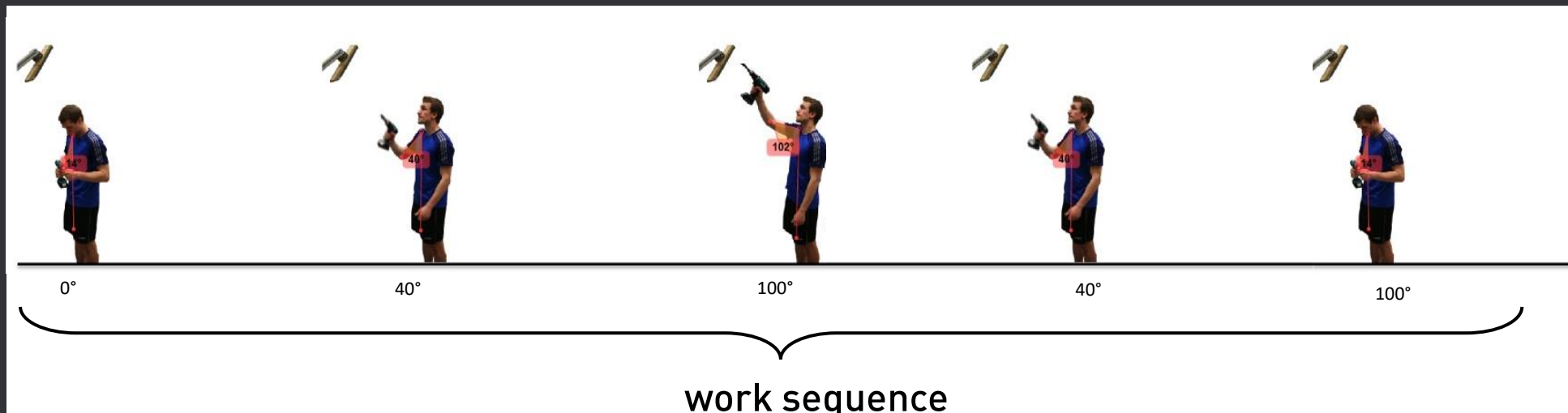


Primary value in using occupational exoskeletons

1. Targeted body areas are those under high load
2. Its use is meant to prevent the development of muskulokeletal ailments or diseases (MSD)



Load reduction – example with drilling



muscular load reduction
caused by the exoskeleton

passive vs. active exoskeletons*

passive exoskeletons



actuation

torsion spring

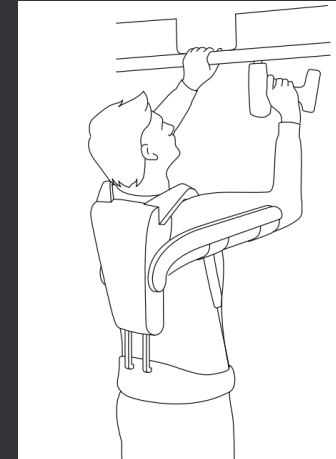
gas strut

flat spring

elastic band

Force support has to be generated by the user and/or gravity

active exoskeletons



actuation

pneumatic (air-pressure)

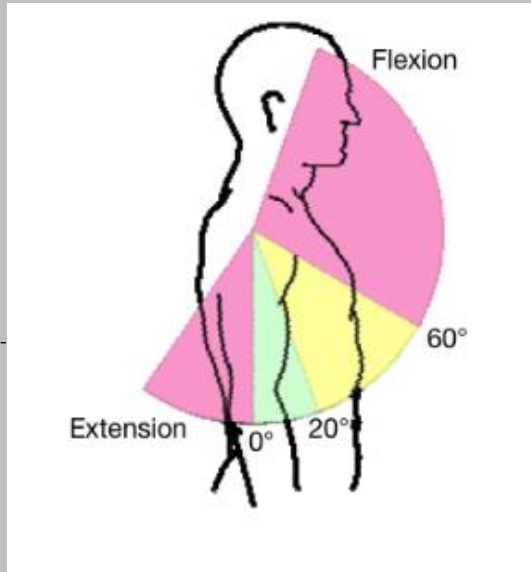
electric motor

Force support is generated by a motor without user input

* All statements are generalized and might not all apply to specific models

Adjustability of exoskeleton support (torque application)

Torque distribution at the shoulder at shoulder flexion (drilling, lifting, holding etc.)

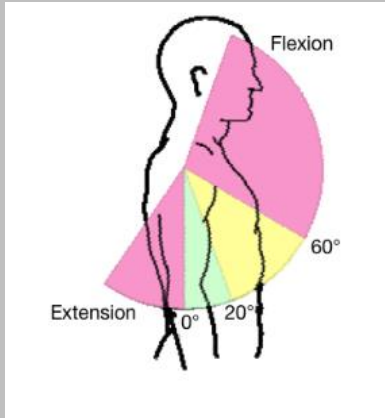


Source: DGUV Information 208-033, DGUV/IfA, 2015

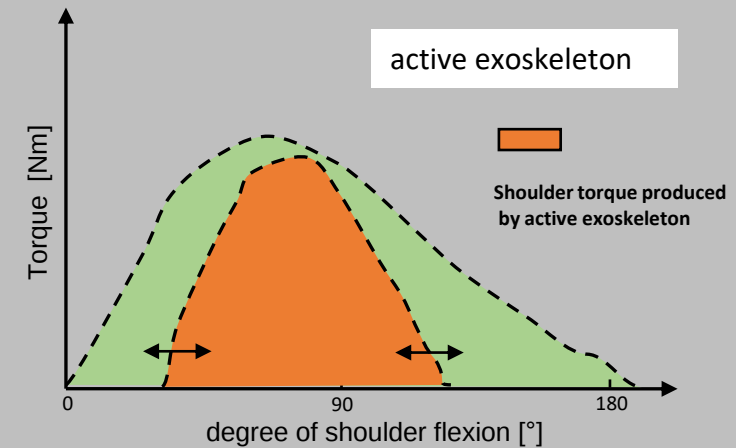
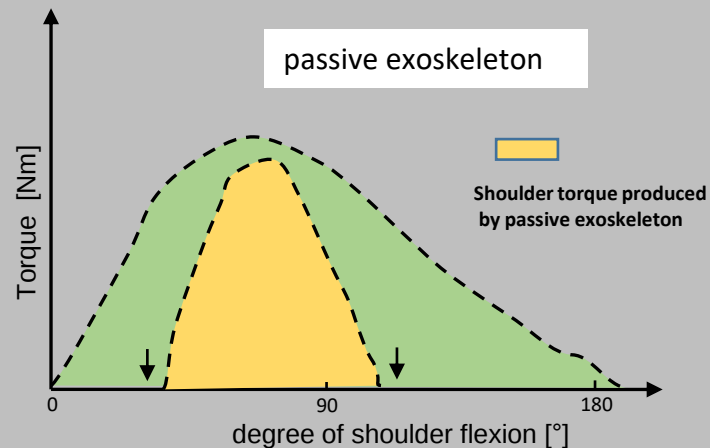
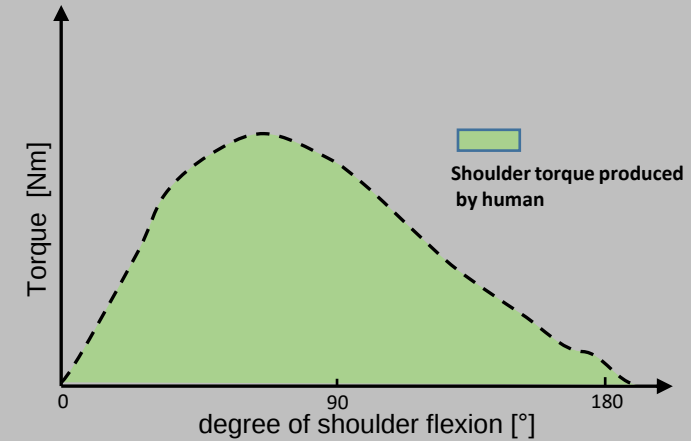


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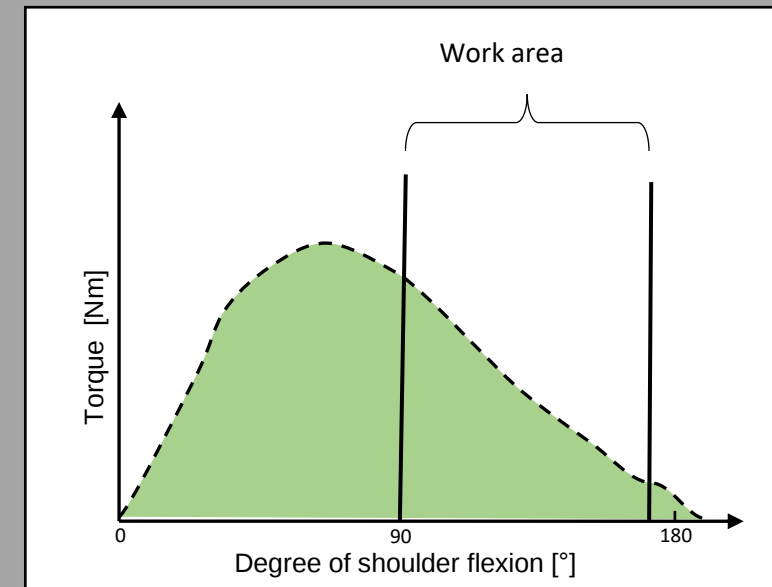
Source: DGUV Information 208-033, DGUV/IfA, 2015



Work area and specific ergonomic angles



- Repetitive motions can be categorized by their main work areas
- These areas are marked by the primary angles in which the task is to be executed



Functional challenges of (passive) exoskeletons

On the way up



direction
of
motion



**Muscle load reduced
(shoulder muscles)**



direction
of
support



direction
of
motion



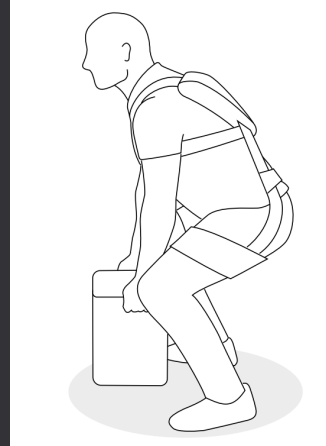
**Muscle load increased
(back muscles)**



direction
of
support

passive vs. active exoskeletons – pros and cons*

passive exoskeletons



pros

lower weight

no external energy source

cons

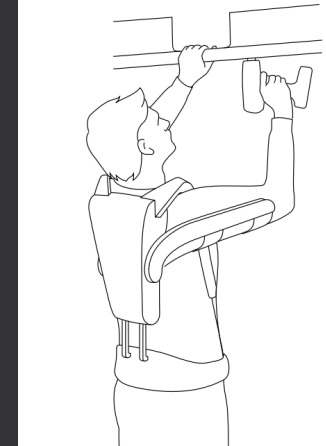
pre-defined dynamics

pre-defined force distribution

pre-defined work area

limited individualization

active exoskeletons



pros

adjustable dynamics

adjustable force distribution

adjustable work area

high individualization

cons

higher weight

needs external energy source

* All statements are generalized and might not all apply to specific models

General outcomes of occupational exoskeleton use*

YES

- reduces the physical load of employees
- extends the working capabilities of employees in the long run (healthy ageing)
- increase the attractiveness of the work environment for new target groups
- booster work safety
- receive feedback on ergonomics such as work density and possible overload

NO

- reduces the amount of employees needed for certain tasks
- increases work load per hour and thereby booster productivity
- enhances the employees capabilities to unknown heights
- get „disabled“ personnel back to physical strenous jobs they can't do on their own anymore

* All statements are generalized and might not all apply to specific models

Do exoskeletons work for us?

Workplace Analysis

Analysis of working scenarios

Reported ailments

Individual and collective exposure

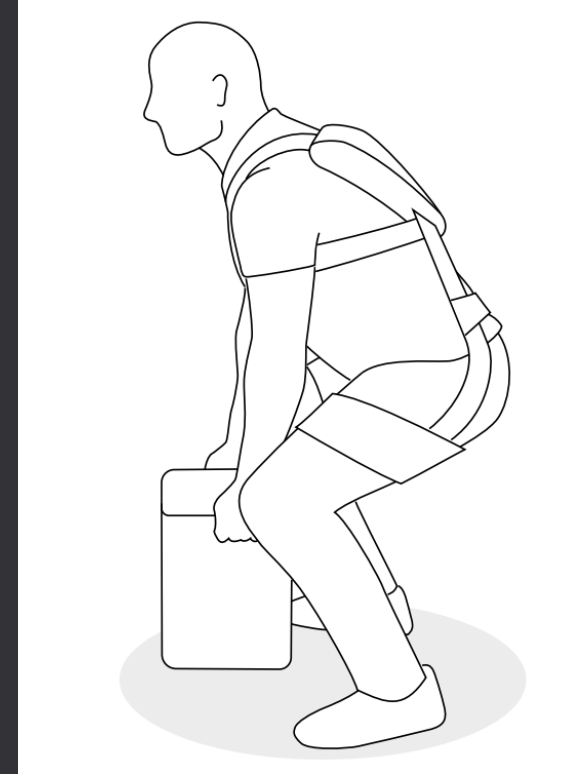
Contextual factors

Tools to be used

Loads to carry

Clothes/Safety garment to wear

Work environment



informed decision

based on self-analysis and information
delivered by the exoskeleton vendor





exoIQ S 700 exoskeleton



- adjustable support level
- support when needed
- adjustable work area
- customizable pre-sets
- work ergonomics analysis

Take home messages

- Exoskeletons can be used to mitigate physical load and might ultimately reduce the amount of physiological ailments
- The use of exoskeletons is workplace specific
- Exoskeletons should be highly adjustable to individual needs
- Integration of exoskeletons at the workplace is to be planned ahead
- Nevertheless - different workers might need different solutions – accept the heterogeneity in your workforce !

Thank you very much for your attention!