Saskia Baltrusch
Heliomare
The Netherlands

A change of perspective

From adapting working environments towards wearing a passive trunk exoskeleton

SPEXOR

Spinal Exoskeletal Robot for Low Back Pain Prevention and Vocational Reintegration

UNIVERSITÄT HEIDELBERG ZUKUNFT SEIT 1386 · ottobock. · Vrije Universiteit Brussel · Jožef Stefan Institute · S2P SCIENCETOPRACTICE · VU VRIJE UNIVERSITEIT AMSTERDAM · heliomare

Affecting 60-80% of people at some point in their lifetime

High economic burden

Occupational health problem

work-related risk factors for low-back pain

Mechanical and aerobic loading

(Waddell & Burton, 2001; Lambeek et al. 2011; Wynne-Jones et al., 2014; Coenen et al., 2014; Griffith et al., 2012)

Need for prevention

Interventions focus on reducing biomechanical risk factors

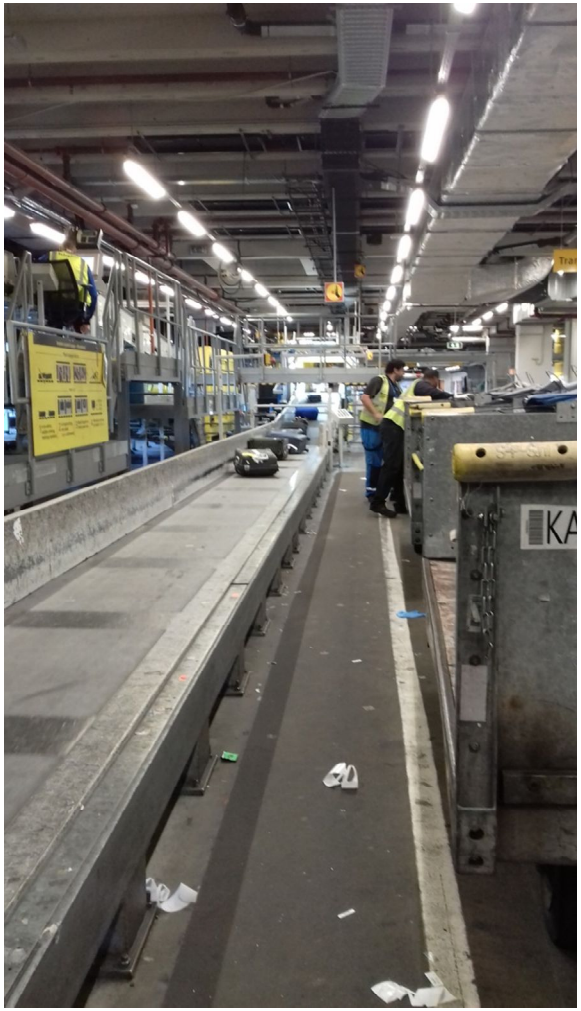
Problems:

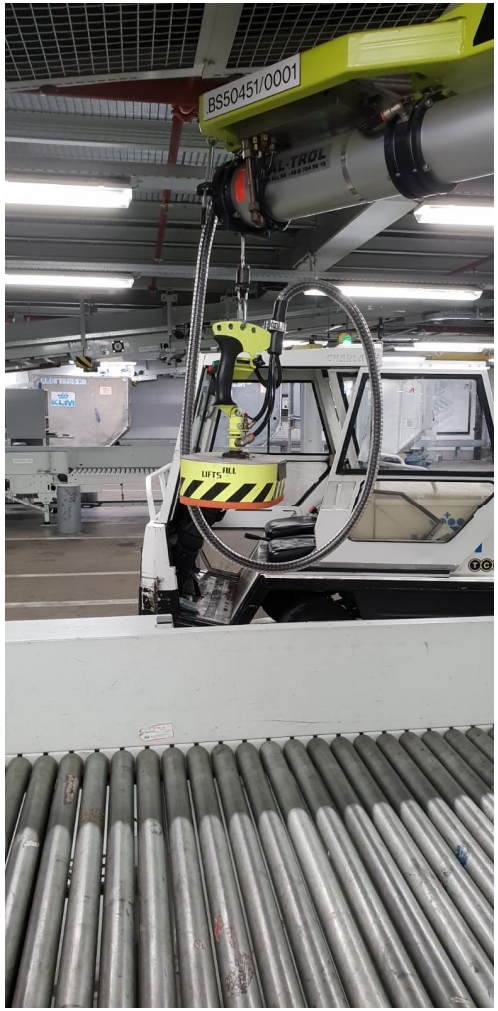
- Ergonomic re-design
- Inefficient working
- Effect sizes are low

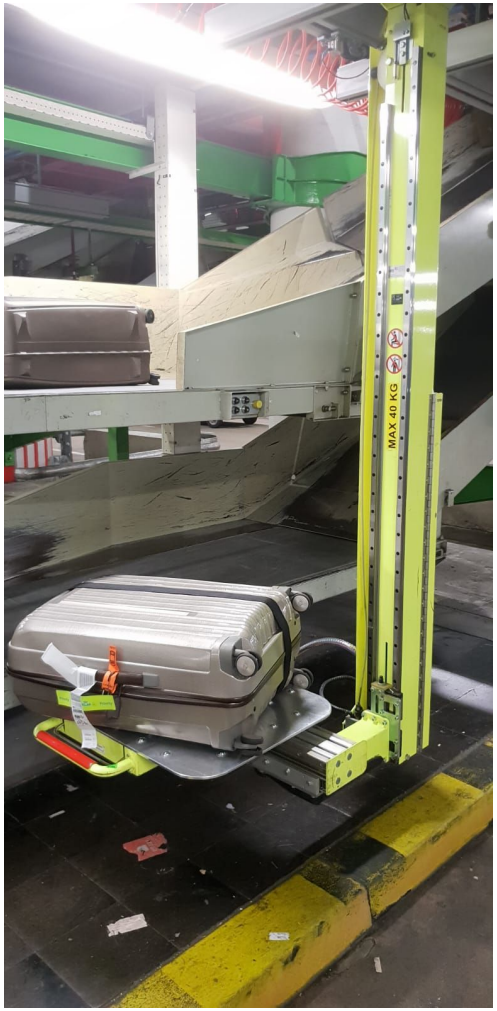
(Faber et al., 2009; Ferguson et al. 2002; Whitfield et al., 2014; van Dieën et al., 1999)


N644UA
KLM

Limitations of ergonomic re-design







SPEXOR | SPINAL EXOSKELETAL ROBOT FOR LOW BACK PAIN PREVENTION AND VOCATIONAL REINTEGRATION

To design and test a novel assistive device

to prevent low-back pain in able-bodied workers

to support workers with low-back pain in vocational reintegration

Laevo (Intespring, Delft, NL)

Design improvements:

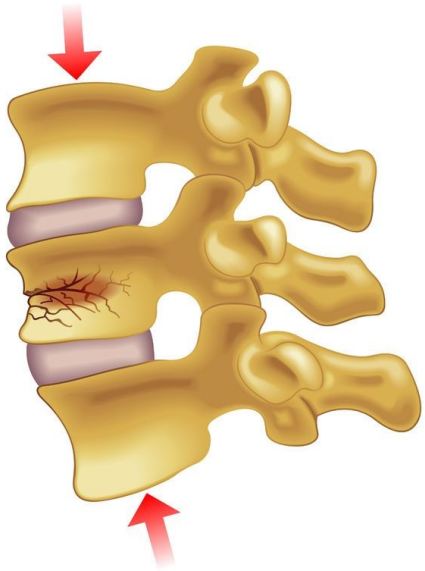
1. Possibility to disengage the device
2. Improved versatility needed
3. More support needed
4. Improved comfort

Compression forces on the spine:

Static : 5000N
Dynamic: 6000N

Aim:
generate a
moment c

Reduce cc
1000-200



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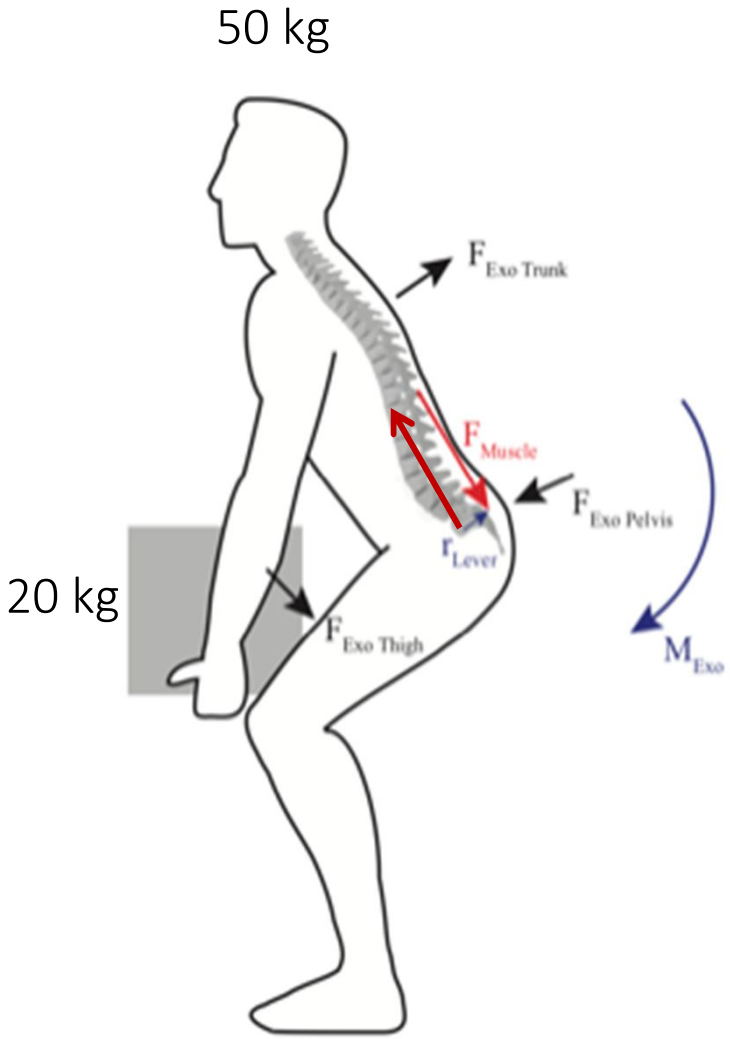
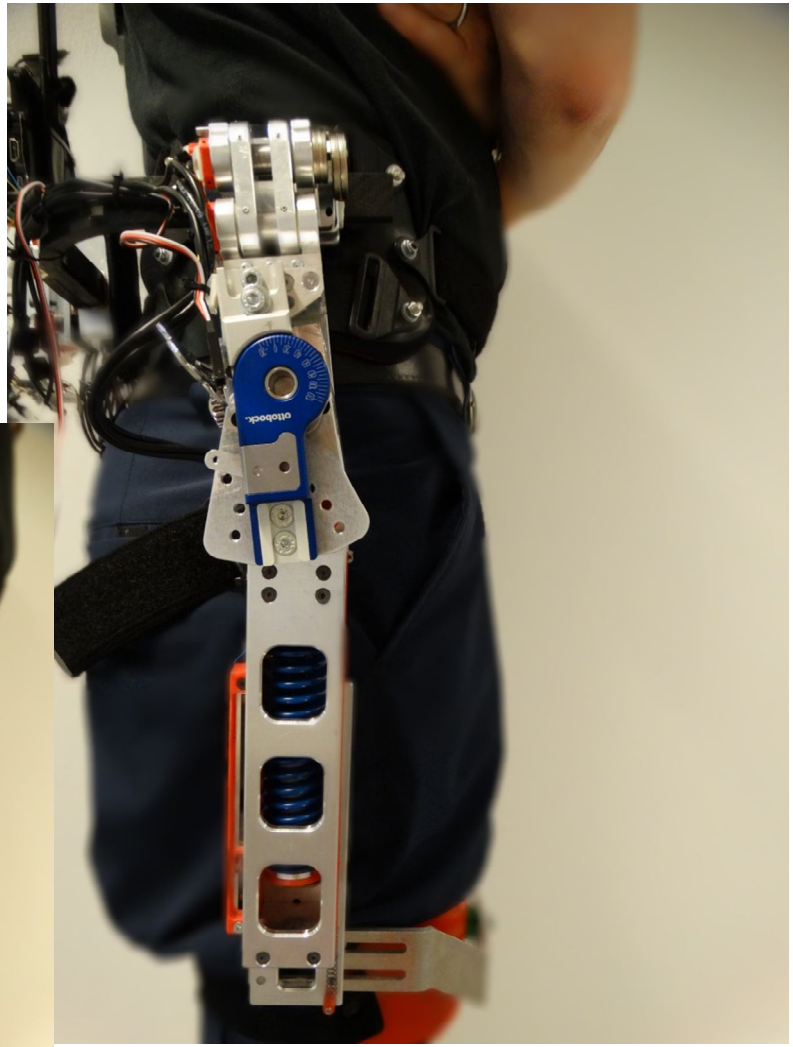


Further developments



Recruitment

- 24 participants
- Average age: 44
- Different occupations
- Two main groups: KLM/Mitsubishi

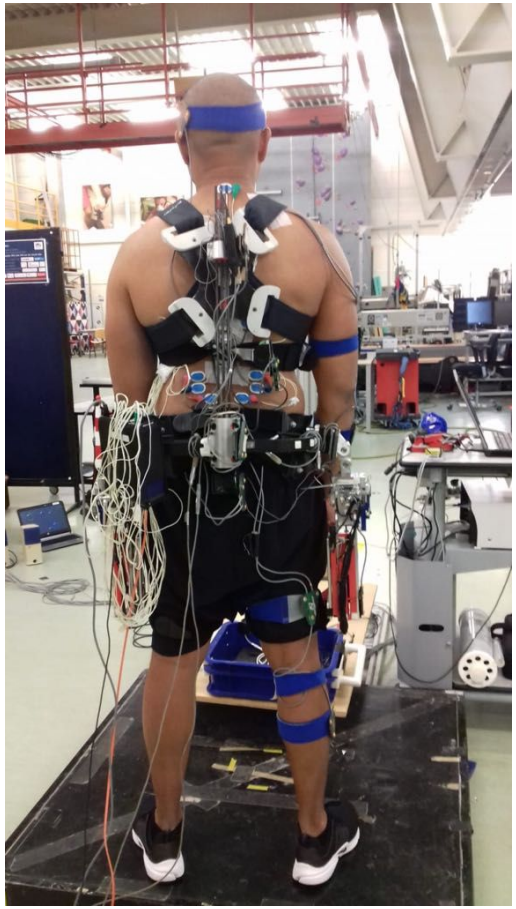
Evaluation of the passive exoskeleton

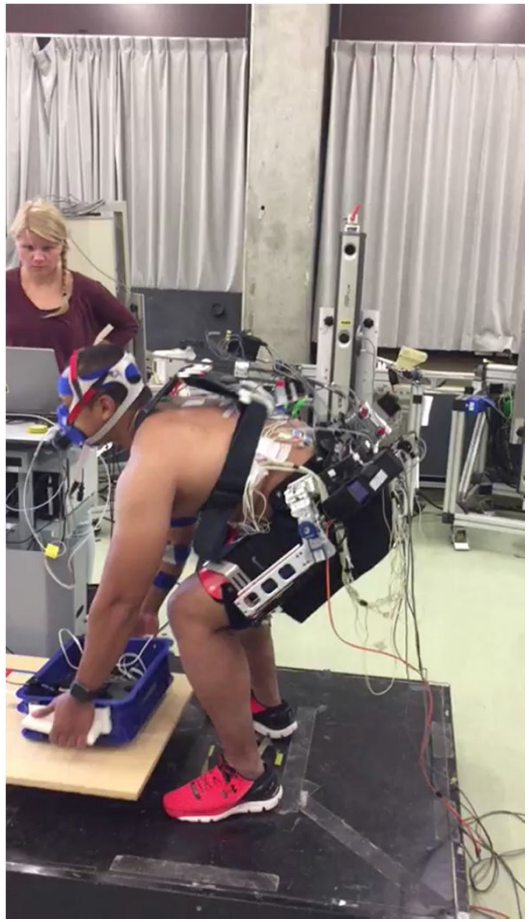
1. Biomechanical testing

2. Effect of the exoskeleton on metabolic costs
3. Effect of the exoskeleton on functional performance

4. Questionnaires to assess Self-Efficacy of workers with LBP with and without exoskeleton

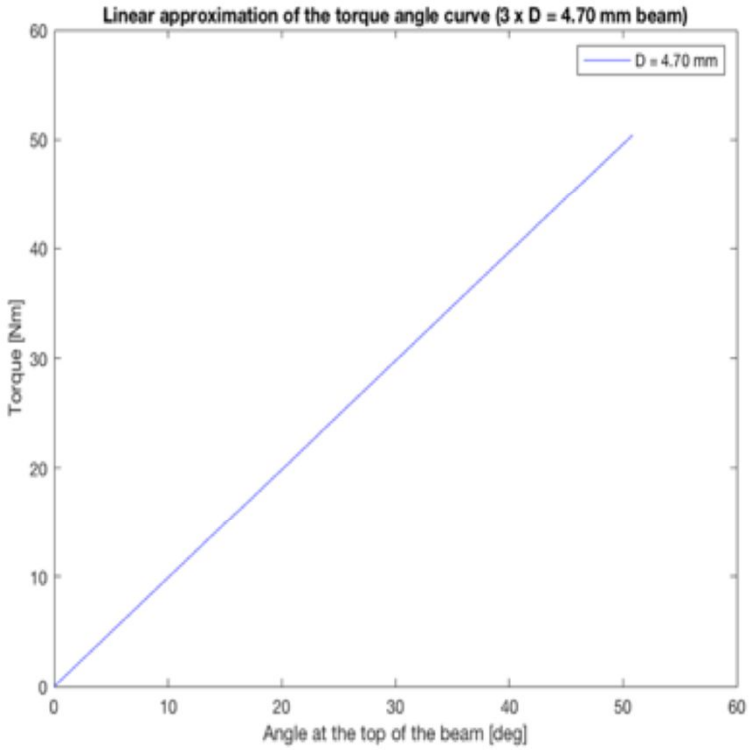
Biomechanical testing

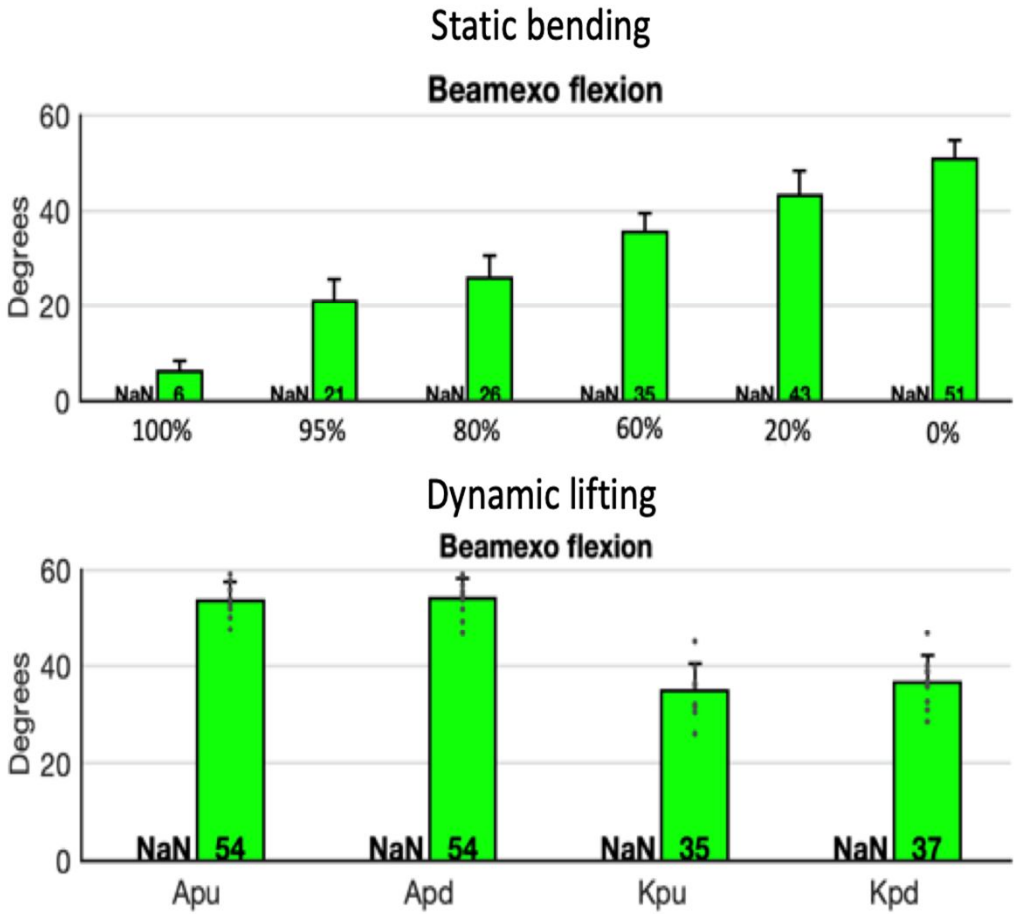




Biomechanical testing

Supporting moment

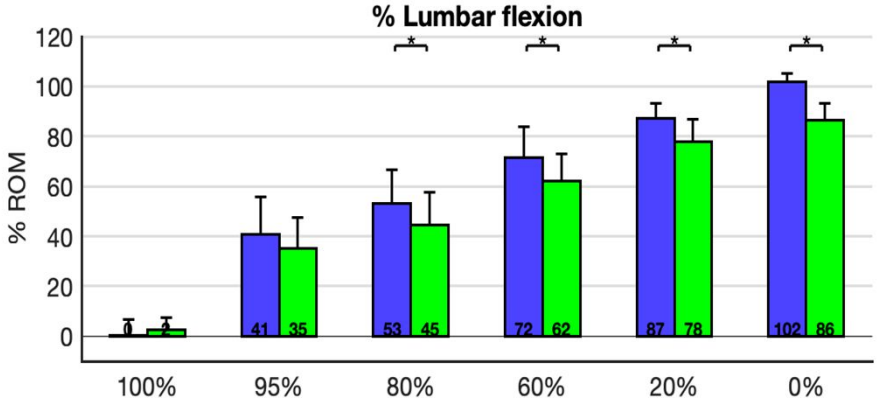




Peak support: 50Nm

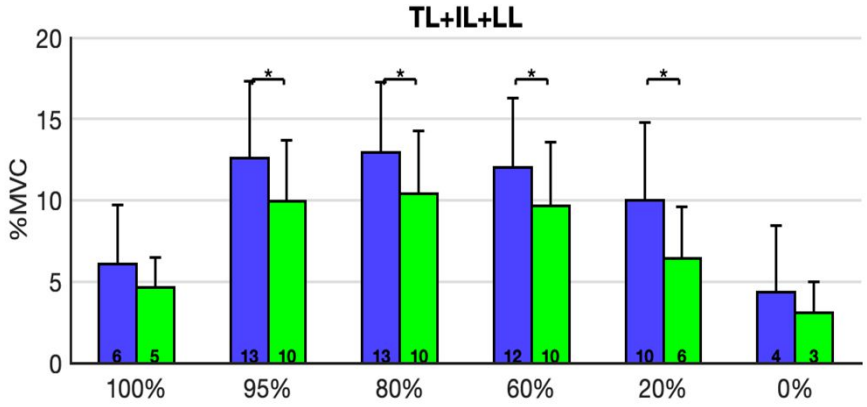
Biomechanical testing

Static bending



Lumbar flexion ↓

Compression forces ↓

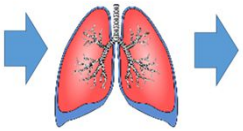


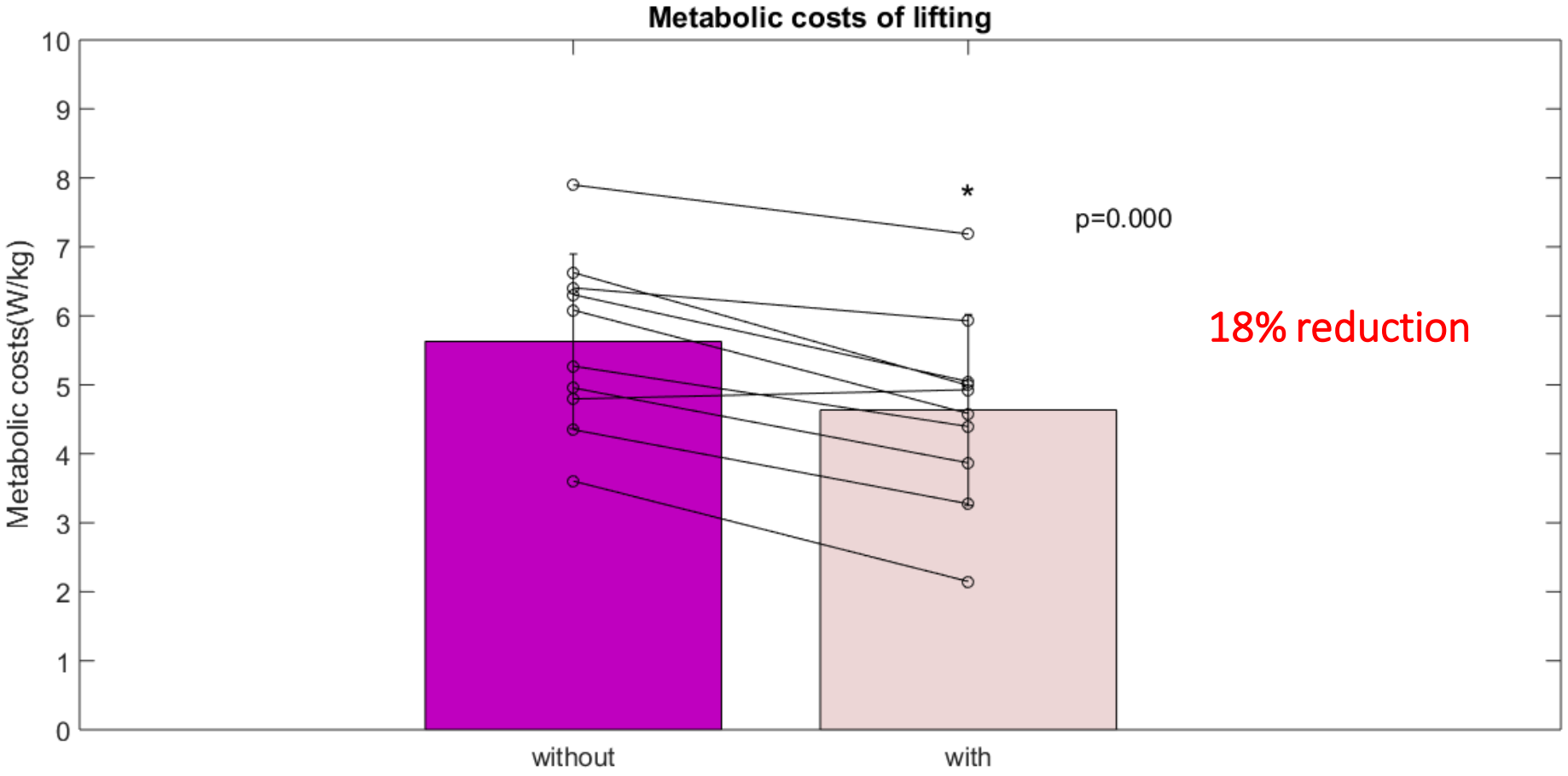
Muscle activity ↓

Compression forces ↓

The passive SPEXOR exoskeleton reduces back muscle activity and lumbar flexion by providing a peak support of 50Nm.

Effect on Metabolic Costs





18% reduction

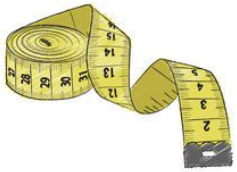
Effect on Metabolic costs

The passive SPEXOR exoskeleton reduces metabolic costs during lifting, hence preventing high aerobic load and fatigue and consequently lowering the risk of getting low back pain.

Effect on Functional Performance

Objective

performance



Subjective

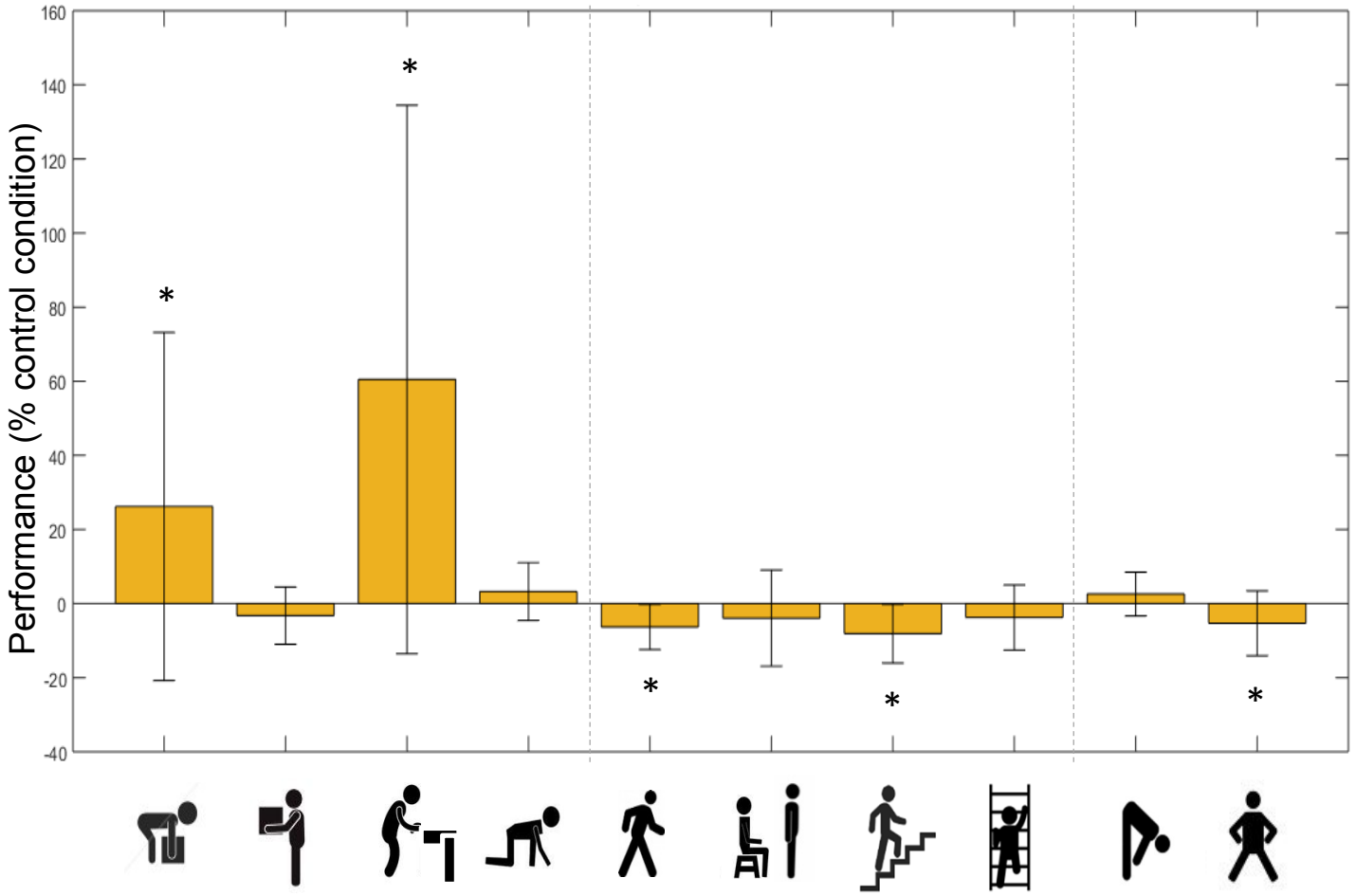
performance

How difficult was the task you just performed?

Very easy _____ Very difficult

Effect on Functional Performance

Objective Performance

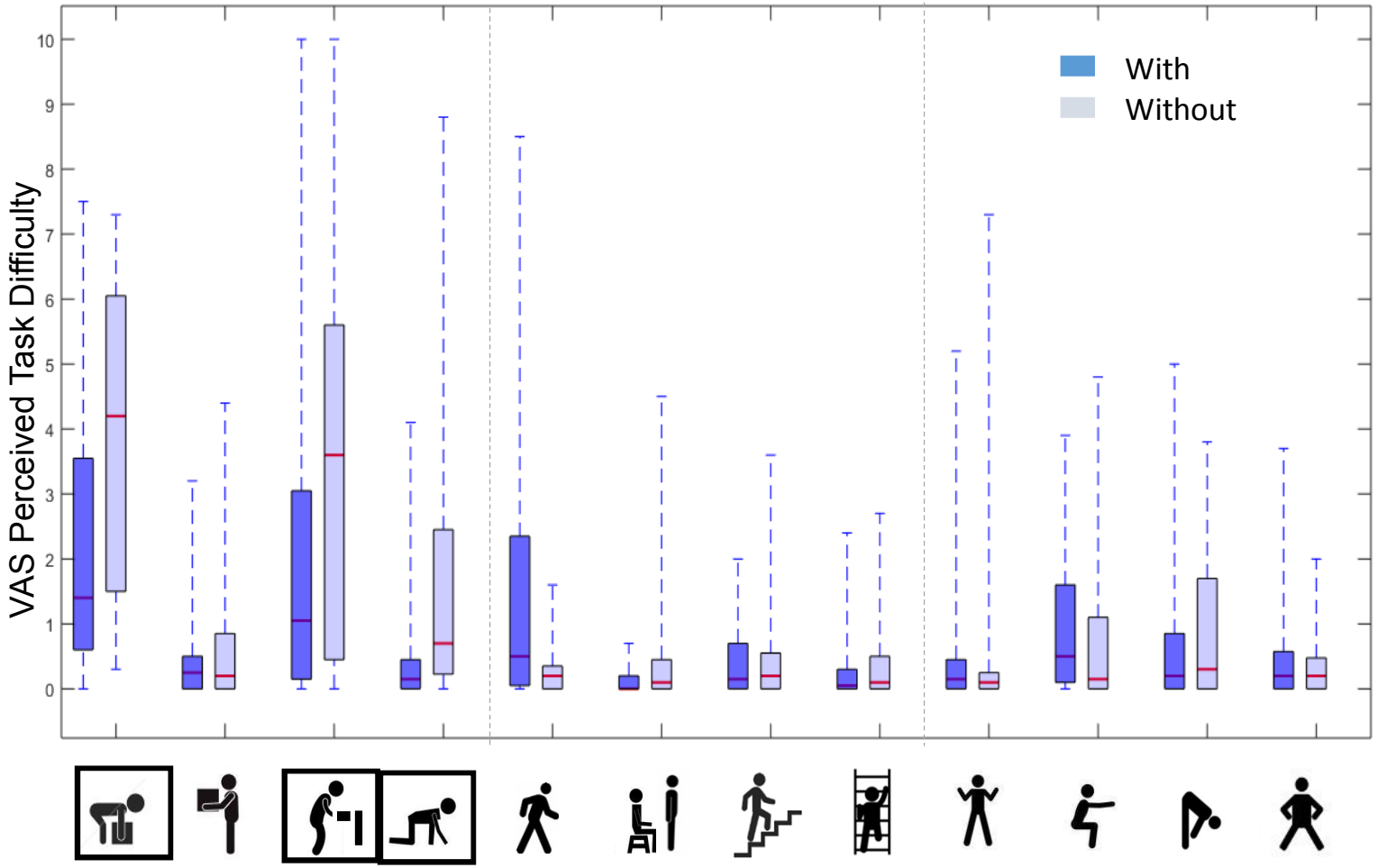


Improved performance

Hindered performance

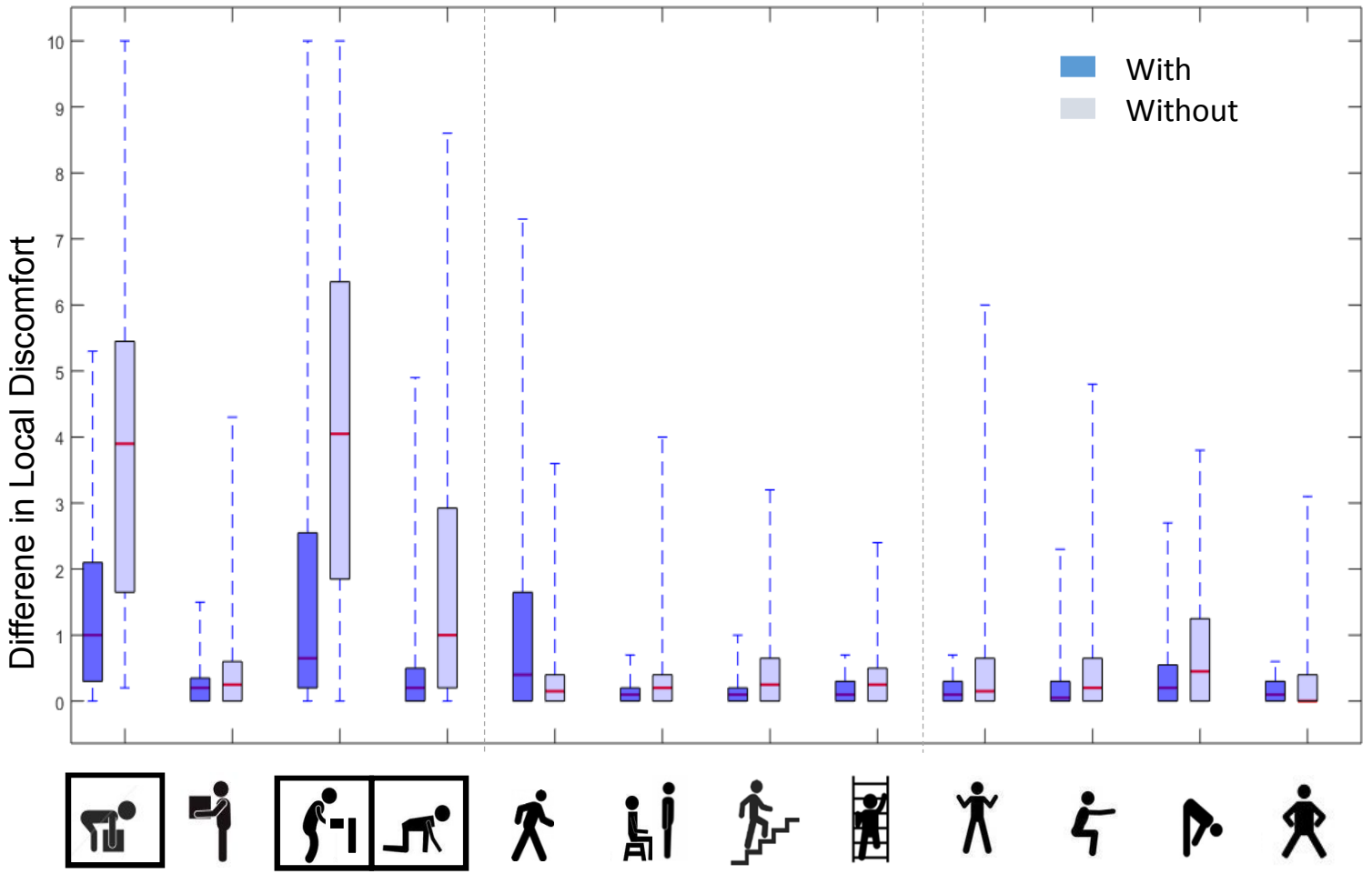
Effect on Functional Performance

Perceived Task Difficulty



Effect on Functional Performance

Local Discomfort in the Lower Back



High discomfort

Low discomfort

The passive SPEXOR exoskeleton supports lifting and static postures, users do not feel hindered by the device and discomfort in the lower back is reduced.

User satisfaction

How would you grade the device?

Would you consider this device for daily use?

42% YES

58% NO

User satisfaction

Category		Median	Interquartile Range	VAS scale
Adjustability	Donning and Doffing	1.9	0.4-4.3	0=very easy 10=very difficult
	Length Adjustment	1.3	0.5-2.7	0=very easy 10=very difficult
Range of Motion		1.4	0.7-2.3	0=not restricted 10=heavily restricted
Efficacy	Reduction of back loading	3.9	1.9-6.9	0=high reduction 10=no reduction
	Support of tasks	4.6	1.3-7.7	0=high support 10=no support
	Interference with tasks	2	0.9-3.3	0=no interference 10=high interference

Weight and Dimension

The passive SPEXOR exoskeleton resolved problems that were encountered with previous devices, such as interference with tasks, discomfort and restricted range of motion.

General comfort could be improved by reducing the weight and dimension of the exoskeleton.

Support level of the Spexor exoskeleton could be improved.

Effect on Self-Efficacy

Modified Spinal Func

		possible		l i m i t e d		impossible
1	Place a can weighing 2 ½ kg above your head.	1	2	3	4	5
2	Work sitting down.	1	2	3	4	5
3	Remain standing for a	1	2	3	4	5
4	Lift a box weighing 5 k					5
5	Place a box weighing					5
6	Prolonged sitting in a f					5
7	Carry a bag weighing					5
8	Use a vacuum cleaner					5
9	Get into a car.					5
10	Take a 5 kg bag in ea					5
11	Place a box weighing					5
12	Work for a prolonged squatting position.					5
13	Wash dishes at a sink.					5
14	Place a box weighing					5
15	Stand for a prolonged position.					5
16	Walk for					
17	Bending					
18	Lift a box					
19	Load Lo dishwash					
20	Take a l					

If you c

If you c

1 ("possible").

sible

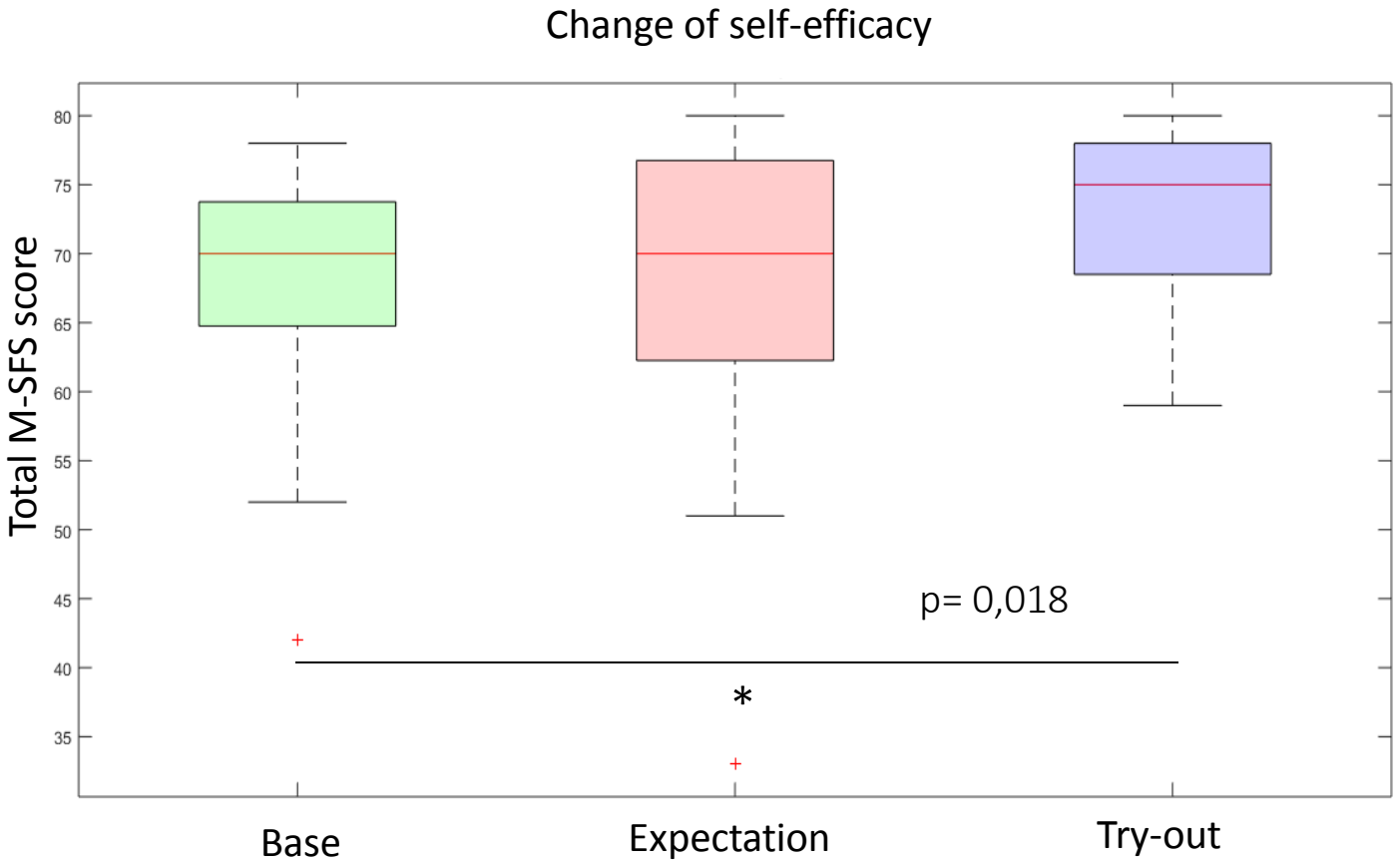
sible

18. Lift a box weighing 25 kg from the floor onto a workbench.

5. Place a box weighing 10 kg into the trunk of a car.

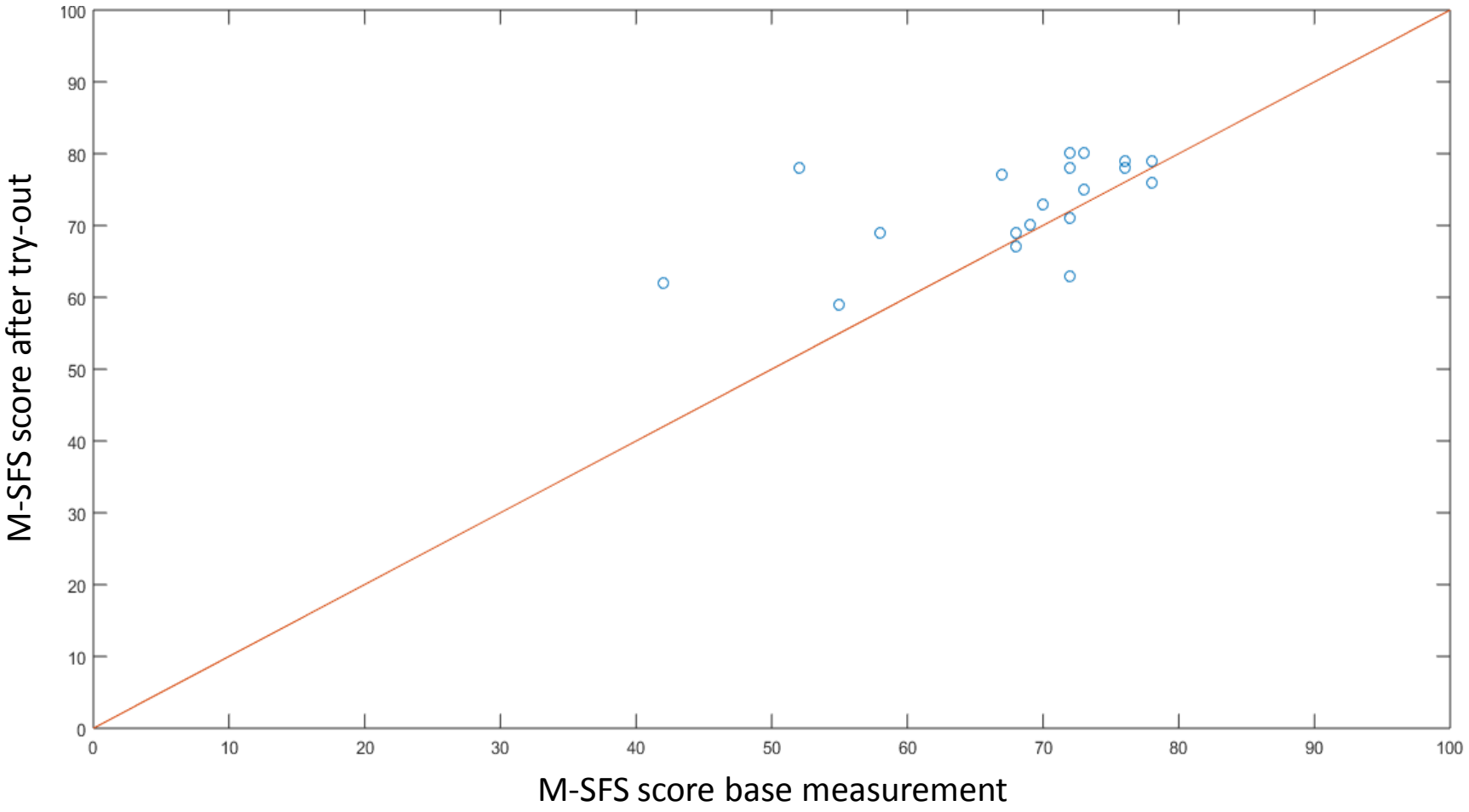
Go through the pictures quickly and don't spend too much time on a question. Your first impression is often the best.

Effect on Self-Efficacy



Effect on Self-Efficacy

Change of total M-SFS score: Individual data

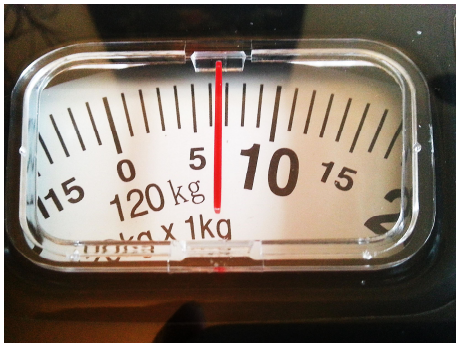


Effect on Self-efficacy

The passive SPEXOR exoskeleton has the potential to increase self-efficacy in people with recurrent low back pain.

Benchmarking

1. Possibility to disengage the device
2. Improved versatility needed
3. More support needed
4. Improved comfort



Contact
Saskia Baltrusch | s.baltrusch@heliomare.nl