Impact of an actuated back exosuit on physiological measurements and user perception during repetitive industry inspired task

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INTRODUCTION – The WHY and WHAT

Low-back pain is a major occupational hazard for industrial workers [1]! This affects their quality of life.

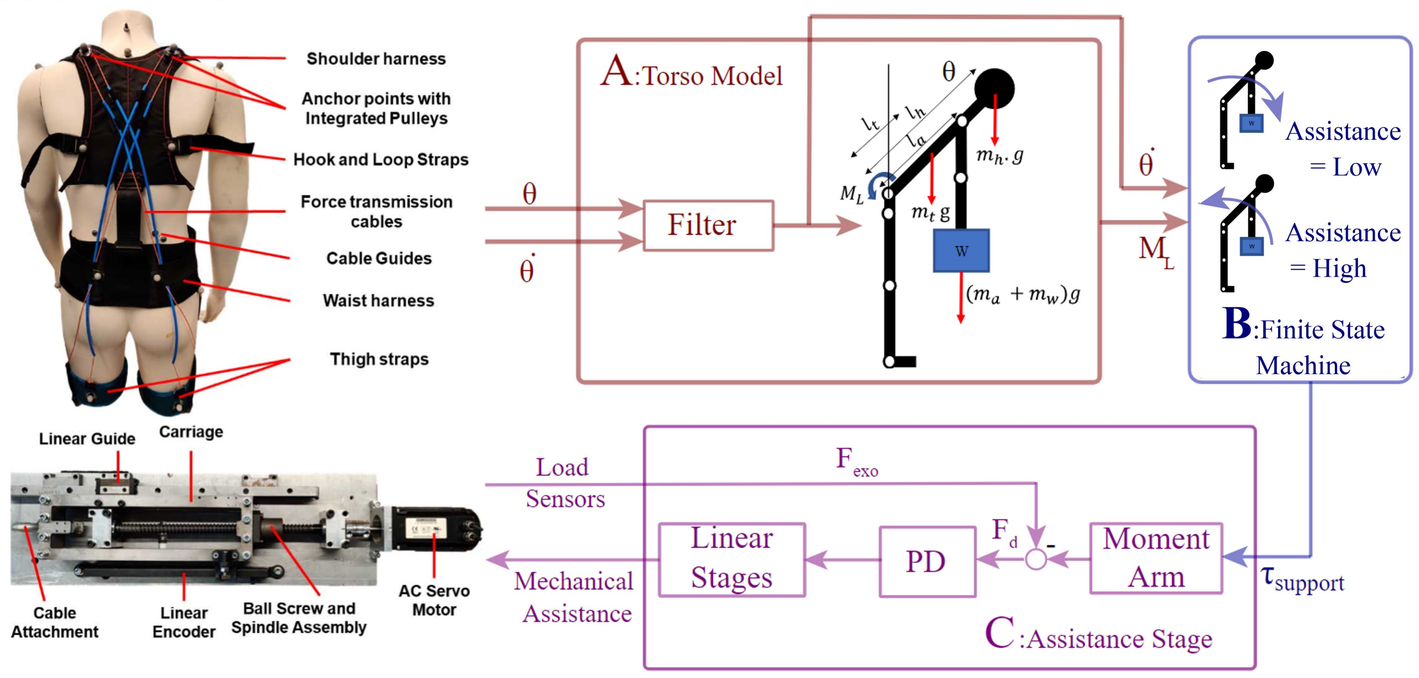
Back support exoskeletons and exosuits are becoming common place commercially. They help offload low back exertion [2]. Soft exosuits are lightweight and allow ease of use. Actuation of exosuits can help offer user and pose specific assistance.

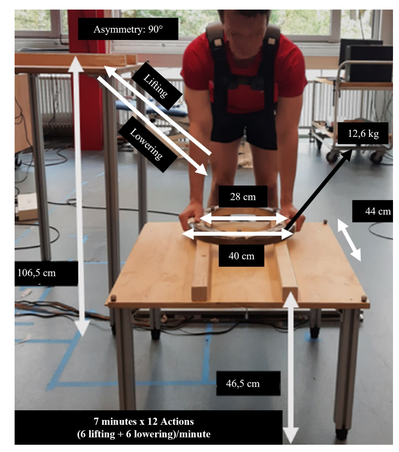
Currently, studies have designed and assessed the influence of actuated exosuits separately on either muscle activity, metabolic costs, or subjective scores. Thus, studies that design exosuits considering both objective and subjective influences are needed.

Here, we describe a novel cable driven soft back exosuit and assess how physiological variables co-change with user perception of the device using multimodal assessments.

↑ Fig. 1. Low back pain is a common complaint among factory workers.

METHODS – The HOW





Scan here for a video of the experimental protocol

↑ Fig. 2. **Soft Exosuit Design**: Neoprene shoulder harness attached to the user using hook and loop straps. Steel cables were routed using pulleys anchored to the back and attached to the thigh straps to create a moment about the lower back. **Control Schematic**: Trunk inclination angle and velocity were measured and used to drive a static torso model to obtain a simplified lumbar moment. The desired torque profiles were converted to required cable forces depending on whether the user is flexing or extending. **Experimental Setup**: Participants performed the experimental protocol on two days, first without the exosuit, and on the second day with the exosuit. They moved the gear between the two platforms repeatedly for 7 minutes at 12 bpm.

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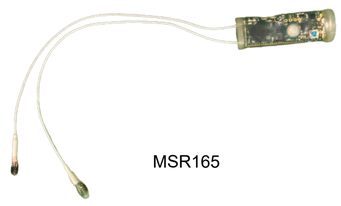

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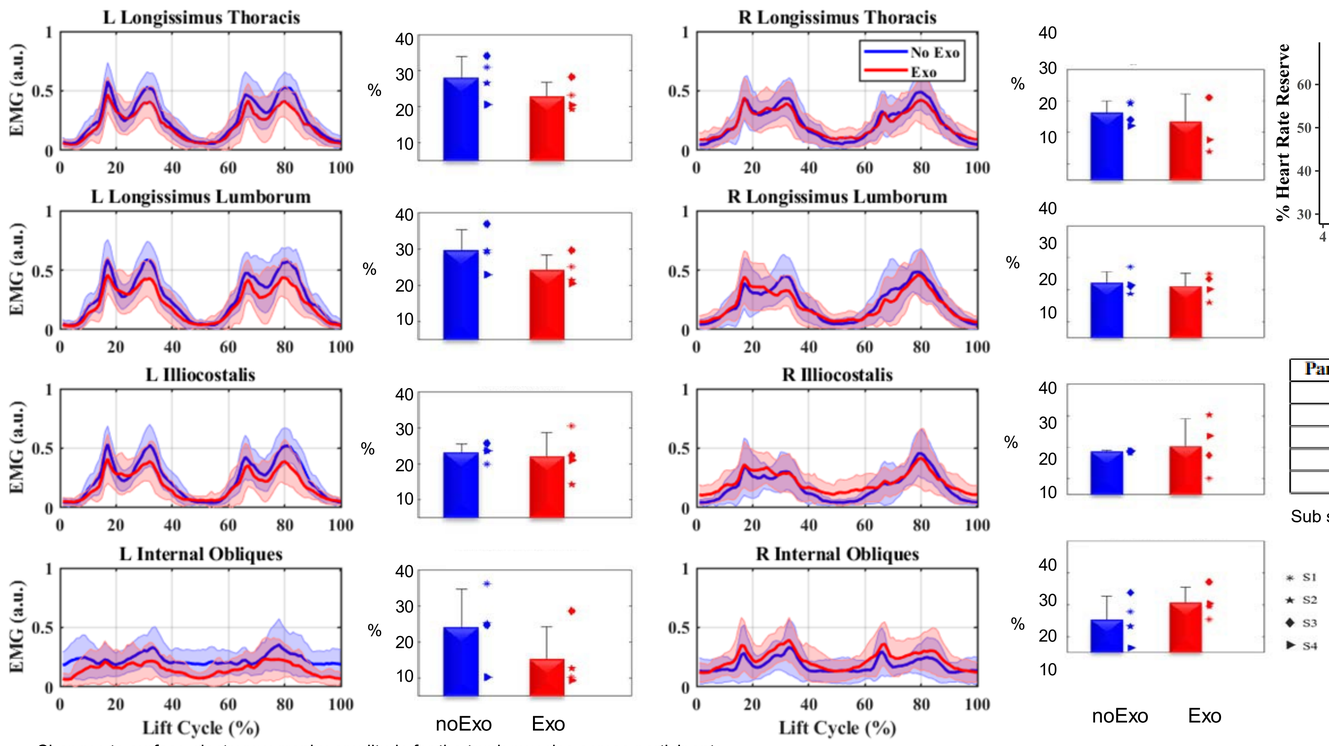
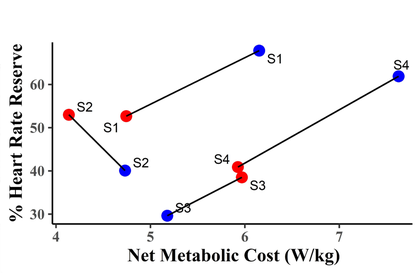
Questionnaires

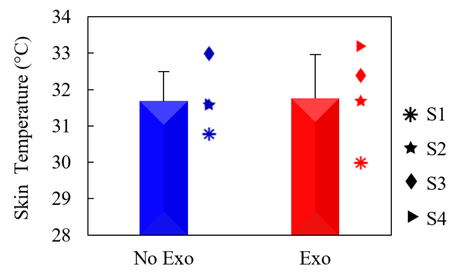
↑ Fig. 3. Objective multimodal measurements were collected from the participants during the experimental protocol. This included surface electromyography, metabolic costs, heart rate, skin temperature. Subjective questionnaires were filled out, including the NASA-TLX, an acceptability questionnaire, and Rate of Perceived Exertion scale.

RESULTS – The KNOWLEDGE



Changes to surface electromyography amplitude for the trunk muscles across participants





Participant	Effort		Frustration		Mental		Performance		Physical		Temporal	
	WO	W	WO	W	WO	W	WO	W	WO	W	WO	W
S1	70	50	40	55	20	25	75	90	75	50	25	15
S2	-	90	-	80	-	70	-	60	-	75	-	95
S3	75	60	0	50	35	70	85	85	65	60	30	20
S4	70	55	15	10	10	10	80	90	80	60	55	60

Sub scores of the NASA Task Load Index questionnaire without (WO) and with (W) the exosuit.

↑ Fig. 4. Subset of the results; changes to the physiological measurements (surface electromyography, % Heart Rate Reserve (PHRR), net metabolic costs, skin temperature) are shown along with the sub scores of the NASA Task load index questionnaire.

Changes in the objective and subjective measures were participant specific. For S1 and S4, muscle activity, metabolic cost, and % Heart Rate Reserve (PHRR), was reduced when using the exosuit, and so was the case for the subjective questionnaires that assessed exertion, physical demand, and effort. The changes were not similar for the other participants, although some of the measured parameters showed an improvement when using the exosuit.

Therefore, we recommend conducting both multimodal physiological and subjective assessments to design and assess appropriate exosuits for the industry.

REFERENCES
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