HOW DOES A PASSIVE BACK-SUPPORT EXOSKELETON INFLUENCE SHORT-TERM ADAPTATIONS IN LIFTING AND GAIT KINEMATICS?

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Summary

Back-support exoskeletons reduce physical strain during manual material handling but may alter movement patterns, increase fall risk, and users may adapt to the device over time. This study investigated short-term adaptations to a soft, passive exoskeleton during repetitive lifting and gait. 12 participants completed lifting and walking tasks before, during, and after 75 minutes of exoskeleton exposure. Results showed changes in trunk and gait kinematics, as well as increased fall risk when donning and doffing the exoskeleton. Interestingly, there were carry-over effects in gait outcome measures and there were no significant adaptation trends during 75-minutes of exoskeleton exposure.

Introduction

Back-support exoskeletons reduce physical demands during manual material handling by providing external assistance during lifting, [1] But it currently, remains unclear whether soft exoskeletons also impose changes in movement patterns and whether users adapt to these changes over time. This study investigated short-term adaptations to a soft, passive, back-support exoskeleton (Apex, HeroWear, USA) on kinematics during repetitive lifting, lowering, and walking tasks. We hypothesized that exoskeleton (EXO) use would initially affect trunk kinematics and variability during lifting but stabilize over time while gait changes would be small and attenuating with adaptation.

Methods

A repeated-measures design consisting of a four-hour session including no-exoskeleton (Pre-EXO), exoskeleton (EXO-adaptation phase), and no-exoskeleton (Post-EXO) trials in an A-B-A protocol. The 75-min EXO exposure consisted of repeated two-handed lifting of a box and walking trials. A convenience sample of 12 healthy young adults (6M, 6F) participated. Outcome measures included trunk flexion angle, range of motion (ROM), flexion velocity, and time to peak trunk flexion during lifting as well as lower limb joint range of motion, peak angular velocity, step length, step width, and minimum toe clearance (MTC) during gait. A piecewise linear regression model was used to evaluate exoskeleton effects during and in-between phases.

Results and Discussion

During lifting (Fig 1), donning the EXO resulted in trunk ROM, peak trunk flexion angle, and peak trunk flexion velocity decreasing by 6-8% ($p<0.001$). These measures increased by 4-8% after doffing the EXO. During gait (Fig 1), doffing the EXO resulted in 2% increases in step length ($p<0.001$) and hip ROM ($p<0.001$), while step width ($p<0.001$) and MTC ($p=0.005$) decreased by 6% and 3%, respectively. During post-EXO, there were carry-over effects for step length, step width, MTC, and hip ROM.

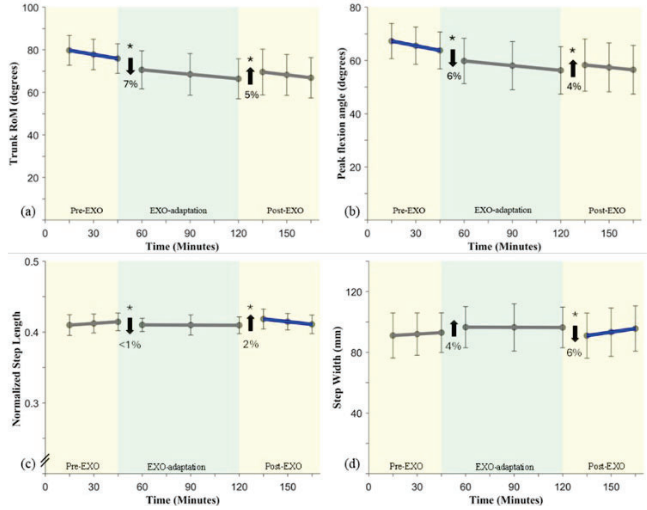

Figure 1: (a) Trunk ROM, and (b) peak trunk flexion angle during lifting, and gait (c) step length, (d) step width.

The Apex exoskeleton significantly altered lifting and gait dynamics when donning and doffing, but no significant adaptations occurred over the 75-minute exposure. During lifting, trunk kinematic changes support prior research demonstrating that exoskeletons can modify lifting strategies to reduce physical strain on the lumbar region [2]. Immediate and carry-over effects during gait may be due to counteractive EXO hip extension torque while walking.

Conclusions

We investigated short-term adaptions to a soft exoskeleton and found immediate and carry-over effects during lifting and gait. However, no significant adaptations were observed over the exposure period. Further understanding of prolonged EXO use should be considered to enable the successful implementation of exoskeletons in industry.

Acknowledgments

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References

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