Effect of distraction on exoskeleton training and adaptation

Julia K. Butterfield[1], Katherine L. Poggensee[1], Steven H. Collins[1]
[1]Department of Mechanical Engineering, Stanford University, Stanford, CA, USA
Email: jbutterf@stanford.edu

Summary

State-of-the-art assistive devices have the potential to restore mobility for individuals with gait impairments and to expand the limits of human movement. However, recent results suggest that significant optimization and training time may be required for users to experience the full benefits of these devices. Typically, any training is done in a tightly controlled environment with minimal distractions for the participant. In our current work, we seek to understand how distraction can affect a participant's adaptation to an exoskeleton in order to inform future decisions about experimental environments. We plan to test five participants in a 6-day continued optimization exoskeleton protocol in a distracting environment. We will compare these results to those obtained in ongoing experimental studies where participants undergo the same protocol but within an environment with minimized distractions.

Methods

In this study, we use ankle exoskeleton emulators that apply an assistive torque during push-off characterized by four parameters [1, 2]. The experimental protocol consists of combinations of six-minute validation blocks and 74-minute optimization blocks. On the first day, participants walk for six minutes in each of three conditions in a randomized double reversal order: normal shoes, unpowered exoskeletons, and a general assistance profile defined as the average optimized parameters from a different group of previous participants. On the second day, participants first experience the 74-minute optimization block during which the torque profile changes every two minutes and four generations of a covariance-matrix adaptation evolution strategy are performed, similar to the optimization period in [2]. Following the optimization block, the participants walk for six minutes in each of four conditions in a randomized double reversal order: normal shoes, unpowered exoskeletons, general assistance profile, and optimized profile. On all subsequent days, participants repeat the protocol of the second day, but walk in both their optimized profile from the end of the second day and their optimized profile from that day. Participants in the distracting environment watch and listen to *Planet Earth* during their 74-minute optimization blocks. The experiments take place in a busy, open lab space with heavy foot traffic and additional noise from adjacently run experiments, varsity athletes performing physical therapy, and audible music from the adjoining university gym. The distraction-limited environment is a small, enclosed room containing only the experimental equipment. The doors to the experimental space have blinds blocking the participants' view of the main lab space. The participants are not permitted to watch television, and other lab members are asked to refrain from entering the room during testing.

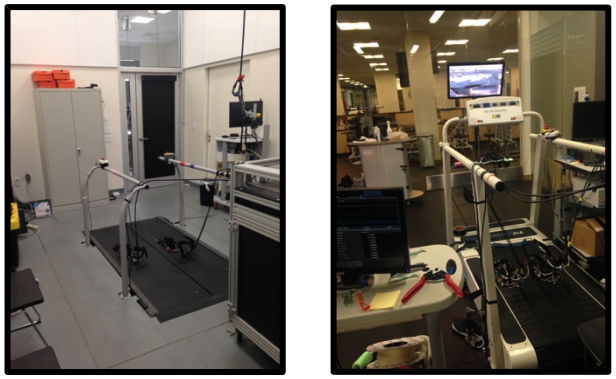

Figure: Distraction-minimized (left) and distracting (right) testing environments.

Results and Discussion

Currently, one participant has completed the full distraction protocol, exhibiting on Day 6 a 32.19% reduction in metabolic cost when walking with the optimized exoskeleton assistance profile compared to walking while wearing the exoskeletons unpowered. Two participants have completed the distraction-minimized protocol, experiencing 33.52% and 25.03% reductions on their sixth days respectively. We expect all 10 participants to have completed the full protocol by the time of Dynamic Walking 2019. By analyzing the final energy cost reductions and rates of parameter convergence across the two groups, we will ascertain how the impacts of distraction compare to the intersubject variability within the groups.

Acknowledgments

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References

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