Human-in-the-loop optimization of ankle-exoskeleton assistance for faster preferred walking speed: a preliminary study

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Summary

Recent success in reducing metabolic energy consumption during walking with ankle-exoskeletons through human-in-the-loop optimization (HILO) [1] opens up opportunities to improve gait assistance for various performance metrics. Here, we present our preliminary study of increasing preferred walking speed. A subject (N=1) was instructed to "walk comfortably" with bilateral-ankle-exoskeleton assistance on a treadmill that adapts to subject's walking speed, and a HILO algorithm using covariance matrix adaptation evolution strategy searched for an assistance torque pattern (i.e., four parameters that define ankle assistant torque patterns) with which the subject choose to walk faster. The 72-minute HILO process tested 72 torque patterns (8 generations of 8 samples and 1 test trial) and found a torque pattern that made the subject walk at a speed 24% faster compared to walking in normal shoes (1.59 vs 1.28 ms^{-1}).

Discussion

The preliminary results promising. First, we observe that the subject chose to walk at different speeds for different exoskeleton assistance (Figure), although the instruction was simply to "walk comfortably." This suggests that ankle exoskeletons can be used to modulate walking speed. Second, the subject stated that it is more comfortable to walk at a self-selected speed than at a constant treadmill speed. We will explore how much of a reduction in energy cost this subject-selected speed can produce by conducting HILO to minimize the cost of transport (i.e., metabolic energy per traveled distance).

Reference

[1] Zhang, J et al., (2017). Human-in-the-loop optimization of exoskeleton assistance during walking. *Science*.

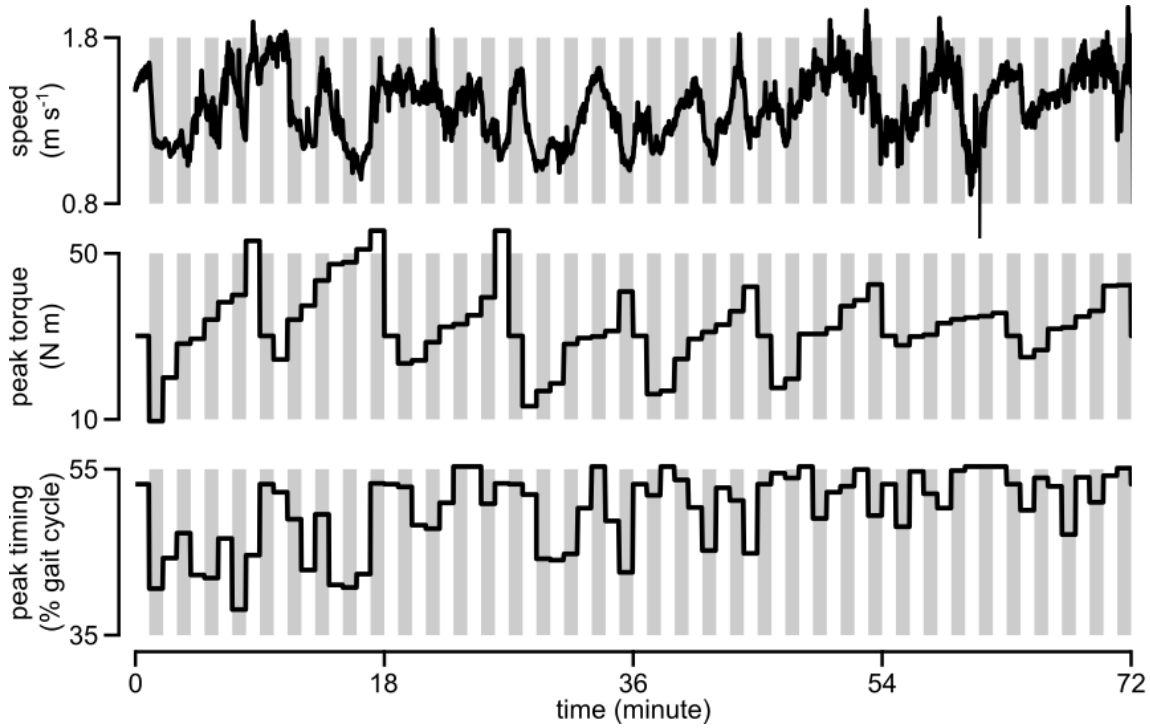

Figure. Walking speed and control parameters during HILO. The top panel shows the subject-selected walking speed, and the bottom two panels show two of the four exoskeleton-control-parameters: amplitude and timing of peak plantarflexion torque. The shaded background indicates different torque patterns. The figure shows that self-selected walking speed changes a lot for different exoskeleton assistance.