Gait Adjustments to Assistive Forces from a Smart Walker

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Abstract of Dissertation

Smart Walkers are often viewed as the next-generation mobility aid; context-aware and equipped with actuators, these devices can be controlled in real-time to move and provide external forces to assist users in ways that were previously not possible. One potential smart feature is improved physical assistance; that is, to use its actuators to reduce the metabolic cost of walking, increase walking speed, and help maintain a healthy gait. While development thus far have relied on the researcher's or developer' s intuition and experience, effectively implementing a physical assistance feature requires a better understanding of the interaction with users, due to the inherent ergonomic challenges involved. The user is physically coupled with the device as they use it for balance and partial body weight support while still mainly relying on their legs to walk. Hence, the external force generated by the Smart Walker may lead to gait adjustments that can counteract any potential benefits afforded by the actuators. This work aims to investigate the user's gait adjustments to the forces generated by a Smart Walker.

In the first study, it was demonstrated that when a constant force is applied, assistive forces increased the walking speed of its users while resistive forces had the opposite effect. More importantly, the perceived exertions reported by users followed a quadratic trend as the force increases from around −20 N to 30 N with minimum exertion occurring at around 1.5% of body weight. While a relatively weak constant force may be helpful, stronger forces may lead to upper body strain or difficulty using the device, which increases exertion.

The second study investigated how users adjust to forces from a Smart Walker when it was used to control the forward speed. This meant that a user only had to walk at the speed targeted by the Smart Walker and they would not have to push the device forward. However, a substantial proportion of users chose to work against the device and overpower it to walk at a more comfortable speed. Furthermore, even when the users matched the speed targeted, they push or pull on the device although this did not result in any observable change in speed.

Study 3 investigated the biomechanical effects of a constant assistive force from a Smart Walker on its users at a range of speeds. Although walking at higher speeds were found to increase the work done by the users on their center of mass in all phases, the assistive force applied decreased the positive work done in the push-off and rebound phases. Additionally, the assistive force supplied reduced the ankle push-off joint power while increasing the hip pull-off flexion power.

In conclusion, a constant assistive force can be used elicit a higher walking speed and can reduce perceived exertions when applied at low magnitudes. However, this also leads to gait changes such as increased knee extensor loading power and hip pull-off flexion power. Furthermore, it was shown that users will choose to push/pull on the device when walking at speeds different from their preferred walking speed. These results can contribute to providing a basis for proposing effective uses for the assistive force from a Smart Walkers.