The effect of forces from a powered walker on spatiotemporal gait parameters and rating of perceived exertion.

Wen Liang Yeoh1, Ping Yeap Loh2, Satoshi Muraki2
1 Graduate School of Design, Kyushu University, Fukuoka, Japan
2 Faculty of Design, Kyushu University, Fukuoka, Japan
wenliangyeoh@kyudai.jp

Abstract

To help deal with their decline in walking ability, older adults often turn to four-wheeled walkers for assistance. However, due to the passive nature of four-wheeled walkers, only users with high walking ability are able to use them safely. The next generation of four-wheeled walkers (powered walkers) is expected to have actuation capabilities such as motorized wheels that can generate horizontal assist forces to better assist walking. While various powered walkers have been developed, the effect of the horizontal forces generated by these walkers on its user’s gait and the effort required to use them are still not well understood. We aim to investigate the effects of different magnitudes of constant forward and backward force from a powered walker on gait parameters and rating of perceived exertion of the user. Results show the participants walked with significantly higher speed and cadence with increasing forward force. No significant results were found for the ratings of perceived exertion.

Keywords: Powered walkers, motorized wheels, mobility, walking aids, horizontal forces

Introduction

Older adults who have difficulty walking rely on their walking aids to move about in their daily lives and maintain their independence. Today, a four-wheeled walker (FWW) or rollator is the mobility aid of choice for people who are able to use it safely [1]. This is because using it most resembles normal walking and requires the least amount of effort [2,3].

However, like other traditional walking aids, FWWs are passive mechanical devices. That is to say it is reliant on its user to generate the physical forces necessary to move around and to use it in such a way that his or her own balance is maintained. This dependence on its user limits the assistance it can provide and hence, the users who are able to use it safely. There is a ceiling to how much walking aids can be improved without addressing its passive nature.

Increasingly, researchers and developers, looking to develop the next generation of walking aids, are adding actuation capabilities to FWW. This leverages the advantages of FWWs while providing an extra avenue to assist a user’s walking. One common way is by adding electric motors to the wheels of the FWW to generate horizontal assistive forces [5]. Nonetheless, the effect of forces from a powered walker on a user’s gait has yet to be investigated. An understanding of how a user responds and adapts to these forces is important in order to inform the conception and evaluation of solutions that utilizes motorized wheels to improve these walkers.

The incorporation of motorized wheels creates an interface or interaction problem in the control of the powered walker. Both the user’s legs and the motorized wheels produce the forces required to move and navigate. Hence, they would have to work together to be effective. Without considering a user’s adaptation to the motorized wheels, the forces generated might work against the user, leading to higher use effort or the user walking with an unnatural gait when using the walker.

Therefore, to start off, we investigated the effect of a constant force applied using a powered walker and the steady-state gait parameters of its users and the perceived exertions during use.

Methods

Eight young and healthy male adults participated in this experiment (age: 25 ± 1.9 years; height: 168 ± 3.0 cm; weight: 61 ± 2.9 kg). All participants provided written informed consent before the experiment.

The participants were asked to walk in a straight line at a self-selected comfortable walking speed for 17 m using a custom-made powered walker under six conditions. The powered walker was made by adding brushless dc motors to the rear wheels of a standard four-wheeled walker. The powered walker was used to generate a constant forward or backward horizontal force during the trials.

The six conditions investigated in this study were constant forces of -18 N, -9 N, 0 N, 9 N, 18 N and 27 N. Positive values indicate a forward force and vice versa.

Four parameters were measured during the trials. Walking speed was measured using the built-in encoders in the brushless dc motors on the powered walker. Cadence was measured using footswitches attached to the heel and toe part of the sole of the participant’s shoes. The participants reported their perceived exertion using the Borg rating of perceived exertion scale.

At the start of the experiment, the powered walker...
handles were adjusted to be level with the participant’s wrist when standing upright. The participants were asked to do their best to walk upright and with roughly 30% of their body weight supported by the powered walker. For each condition, the participants practiced walking with the powered walker for 3 minutes. One-way repeated ANOVAs were performed for the parameters measured. If a parameter was found to show significant difference, polynomial contrast were analyze the trends present.

Results

The results are shown in Figure 1 (mean ± s.d.). There was significant effect of force on self-selected walking speed, $F(2.16, 18.26) = 20.75, p < 0.05$ and cadence, $F(5, 35) = 11.59, p < 0.05$. Ratings of perceived exertion showed no significant difference, $F(1.84, 12.85) = 1.60, p = 0.24$.

Significant linear and quadratic trends were observed for self-selected walking speed, indicating that participants found it more comfortable to walk at a higher speed at higher forward force. There was also a significant linear trend for cadence, suggesting cadence increased proportionally with increasing force. While no significant difference was observed for perceived exertion, the lowest mean was at 9 N and the two highest was at -18 N and 27 N.

Discussion

The higher walking speed at higher forward force suggests horizontal forces reduces the effort required to walk faster. The quadratic trend with increasing horizontal force observed may be due to the user finding it harder to control the powered walker at higher forces.

The proportional increase in cadence with increasing force showed that the user can be induced to walking with a higher cadence by propelling the walker forward and with a lower cadence by braking the walking.

Although no significant difference was observed for ratings of perceived exertion, a parabolic pattern can be seen. The lowest rating reported was at 9 N with increasingly higher ratings as we move towards the extreme ends of the forces investigated. This suggests that if significant force is applied by the powered walker, careful considerations need to be taken to avoid increasing the effort required to use them.

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Figure 1: Effect of different force settings on, a) self-selected walking speed, b) cadence, c) rating of perceived exertion