Adaptive Split-belt Treadmill May Improve Paretic Propulsion in People with Chronic Stroke

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Summary

Stroke affects millions of people worldwide, and post-stroke therapy often focuses on improving walking function. Propulsion (push-off) is an important aspect of walking and targeting impaired paretic propulsion could improve walking outcomes. Although treadmills are used in rehabilitation, they show mixed effectiveness. We developed an adaptive split-belt treadmill (sATM) to encourage increased unilateral propulsion by preferential weighting. Five stroke survivors and five able-bodied participants walked on the sATM for four trials with varied propulsive weighting. We hypothesized that paretic propulsion would increase with increased weighting with no difference in walking speed. Nine participants increased peak paretic propulsion with increased propulsive weighting. This suggests that the sATM could act as a beneficial tool to improve gait rehabilitation.

Introduction

Stroke is a leading cause of disability with over 100 million stroke survivors worldwide [1]. Weakened muscles on the affected (paretic) side decrease propulsion (push-off) during walking which contributes to lowered walking speeds [2]. Fixed-speed treadmills are used in clinical settings for post-stroke rehabilitation but show mixed effectiveness and limit healthy stride-to-stride variability [2]. Adaptive treadmills (ATM) allow for healthy variability and promote walking speeds closer to overground speed, but do not target the paretic side [2]. Split-belt treadmills can decrease gait asymmetries but also run at fixed-speeds and show mixed effectiveness [3]. Therefore, we developed a split-belt adaptive treadmill (sATM) that can be modified to promote increased unilateral propulsion to maintain comfortable walking speeds. The purpose of this preliminary study was to determine the effect of preferentially weighting paretic (unilateral) propulsion on the sATM. We hypothesized that increased preferential propulsion weighting would increase unilateral propulsion and decrease propulsion asymmetry in people with chronic stroke (PwCS) and healthy adults.

Methods

For this preliminary study, N=5 PwCS (67.2±7.6 years) and N=5 neurologically healthy participants (25.6±2.2 years) performed a series of trials on the sATM. The sATM updates the speed of each belt independently at each step using the current belt speed, limb propulsion, and position of the participant on the treadmill. Participants performed four walking trials for 2 min each where the propulsion gain (γ) was varied on the paretic (stroke survivors) or assigned "paretic" side (healthy participants) such that $\frac{\gamma_{paretic}}{\gamma_{non-paretic}} = 1$, 1.25, 1.5, 1.75 (Normal, Low, Medium, High) in random order. They were asked to walk at a comfortable walking speed and maintain similar speeds between belts. For each condition, they were given up to 5 minutes to achieve a comfortable speed. Outcome measures were walking speed and peak propulsive forces.

Results and Discussion

Peak paretic propulsive forces and walking speed were compared for all four conditions (Fig 1). Nine participants had a higher average peak propulsive force in at least one preferentially weighted condition. S1 showed clinically significant increases (0.8 %BW) [4] in peak propulsive forces for the Low, Medium, and High conditions compared to the Normal condition (Fig 1A). Walking speeds were within 0.2m/s between belts for each participant. Our findings support our hypothesis – preferential weighting of propulsion encourages increased propulsion. The heterogeneity of responses may be due to differences in baseline performance and perceived exertion. Future work will involve increasing the sample size to determine the effect of preferential weighting on the sATM.

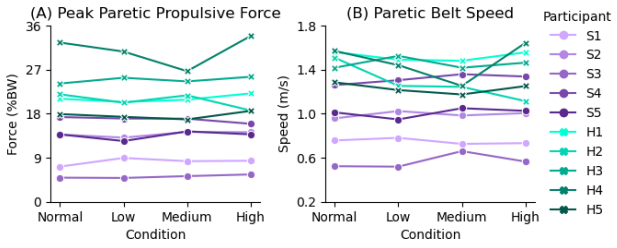

Figure 1: (A) Peak Paretic Propulsive Force. (B) Paretic Belt Speed. Solid lines represent average values for each participant. Circle markers represent PwCS, while cross markers represent healthy participants.

Conclusions

The present study suggests that an sATM can be preferentially weighted to encourage increased paretic propulsion while maintaining comfortable speeds. Tuning the propulsive weighting to individual capabilities could improve propulsion during walking in a heterogenous stroke population.

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References

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