Evaluation of Propulsion Force Adaptations in Post-Stroke Individuals in Response to Asymmetric Walking

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Summary

A primary post-stroke rehabilitation target is gait speed. Propulsion forces directly contribute to walking speed and have been shown to be asymmetric in long-term post-stroke individuals. Thus, improving propulsion force symmetry is a promising rehabilitation target for increasing walking speed. Here, we investigate the utility of asymmetric walking to induce positive adaptations and hypothesize that propulsion force asymmetries will decrease following the perturbations. Analyses showed that differences between limbs decreased over the protocol and were related to walking speed increases.

Introduction

Post-stroke individuals often suffer from neuromuscular impairment and significant losses in motor control [1]. These impairments manifest in gait asymmetries that cause reductions in walking speed. One post-stroke asymmetry that is of particular importance is anterior ground reaction force (aGRF), or propulsion force, asymmetry as it directly contributes to walking speed.

Previous studies have utilized asymmetric walking to target spatiotemporal asymmetries in post-stroke gait [2], but here we investigate its utility to induce aGRF adaptations toward symmetry, and thus its effectiveness as a rehabilitation intervention to increase walking speed post-stroke. We hypothesized that asymmetric walking would induce aGRF adaptations toward symmetry, and that reduced between-limb differences would correlate to increases in walking speeds. These findings would reveal the continued fine motor control capabilities of post-stroke individuals, as well as the ability of asymmetric walking to improve aGRF symmetry and increase walking speed.

Methods

Four post-stroke individuals (mean ± standard deviation; age: 65.0 ± 3.9 yrs; time since stroke 112.3 ± 183.4 months; 1 female and 3 males; self-selected walking speed: 1.26 ± 0.29 m/s) completed the walking protocol. At the beginning of each session, participants performed baseline trials to assess their aGRF asymmetries. They then completed two, ten-minute asymmetric trials with each being immediately followed by five-minute response trials. A linear mixed effects model was fit to determine the trend in aGRF differences at the beginning of each session. Lastly, a Pearson correlation analysis was performed to determine the relationship between aGRF differences and walking speeds.

Results and Discussion

Asymmetric perturbations produced progressive positive aGRF adaptations over the course of the protocol, shown in the baseline trials (Fig. 1). Between-limb aGRF differences showed a decreasing trend over the protocol (p=0.09), and improvements in symmetry were highly correlated to increasing walking speeds (p=0.002) (Table 1).

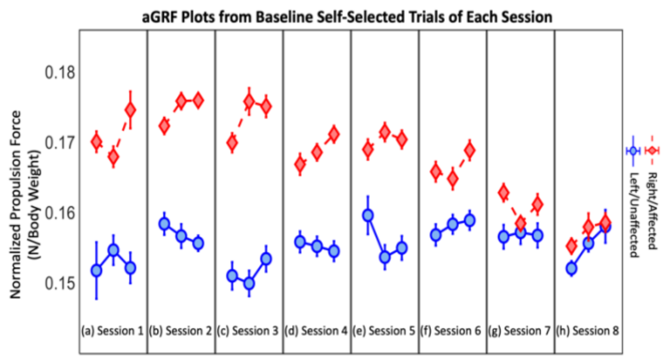

Figure 1: Average minute-by-minute aGRF plots for a post-stroke subject's baseline trials over the protocol's eight sessions.

These results suggest that asymmetric walking perturbations induce adaptations in motor control and promote motor learning, demonstrated by the reduction in between-limb aGRF differences from the first session to the last.

Conclusions

Asymmetric walking was successful in producing motor control adaptations, shown by the smaller between-limb aGRF differences at the end of the protocol. These results suggest the utility of asymmetric walking as an individualized rehabilitation intervention post-stroke to improve aGRF symmetry and thus increase walking speeds.

References

[1] Barroso FO et al. (2017). *J Biomech*, **63**: 98-103.
[2] Reisman DS et al. (2007) *Brain*, **130**: 1861-1872.

Table 1: Linear mixed effects model fit to aGRF percent differences across baseline trials ($R^2 = 0.85$), and Pearson correlation analysis between propulsion force percent differences and self-selected walking speeds (aGRF Difference x Speed) over the course of the protocol.

Term	Value	95% Confidence Interval	p-value
Session	-2.16	[-4.42 0.12]	0.09
Speed	-23.1	[-71.8 25.3]	0.39
aGRF Difference x Speed	-0.54	[-0.76 -0.22]	0.002*

* significant value (p-value < 0.05)