Gait speed-dependent asymmetry in foot placement control in persons with chronic stroke.

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Summary

This study aimed to evaluate foot placement control across a range of speeds in persons with chronic stroke (PwCS) and healthy controls (HC). Sixteen PwCS and 21 HC walked on a treadmill at varying speeds, ranging from 0.2 m/s to 1.6 m/s or up to the individual's maximum gait speed. Mediolateral (ML) foot placement control was assessed using the root mean square error between predicted and actual foot placements. Mixed models revealed poorer ML foot placement control at low speeds in both groups. At walking speeds higher than comfortable, the HC demonstrated improved and more consistent ML foot placement control with increasing speed, while PwCS exhibited worsening paretic control and non-paretic control remained stable. The increased motor control deficits at higher gait speeds emphasizes the potential benefits of integrating speeds above CWS into therapy.

Introduction

The foot placement strategy is the primary control mechanism for mediolateral (ML) balance during gait. This strategy seems impaired in PwCS, particularly in paretic steps, contributing to instability and fall risk [1]. While foot placement control seems gait speed-dependent and less tightly regulated at low speeds in healthy adults, this relationship remains unexplored in persons with chronic stroke (PwCS). As PwCS often reports increased balance difficulties at speeds below and above comfortable walking speed (CWS), this study characterized foot placement control across a range of speeds in PwCS and healthy controls (HC).

Methods

Sixteen PwCS and 21 HC walked on a treadmill at varying speeds. HC walked at speeds ranging from 0.2 m/s to 1.6 m/s, while PwCS walked from 0.2 m/s up to the individual's maximum gait speed, increasing in 0.2 m/s increments. Foot placement control was evaluated using foot placement deviation, defined as the root mean square error between predicted and actual foot placements. Predicted foot placements were derived from a linear regression model [2], using mediolateral (ML) center of mass position and velocity at heel strike as predictors.

Mixed models were used to assess the relationship between gait speed and foot placement deviation. Analyses were conducted separately for speeds below and above the individual CWS. The models included gait speed as a fixed effect, with an additional fixed effect for leg (paretic vs. non-paretic) in PwCS. Random intercepts and slopes were incorporated to account for individual variability. The best-fitting model was determined by comparing linear, exponential, and quadratic models based on the lowest Akaike Information Criterion (AIC).

Results and Discussion

The best-fitting models were linear below CWS and quadratic above CWS for PwCS, as well as for HC. In PwCS, foot placement deviation decreased (improved control) by an average of 0.18 cm per 0.1 m/s below CWS (β = -1.8, SE = 0.6, p = 0.01), with no significant difference between the paretic and non-paretic legs (p = 0.62). At CWS, no deviation difference was observed between legs (p = 0.46). Above CWS, foot placement deviation remained unchanged for the non-paretic leg (β = 0.2, SE = 0.3, p = 0.63) but increased (worsened) for the paretic leg relative to the non-paretic leg (β = 1.2, SE = 0.4, p = 0.02). In HC, foot placement deviation was higher (worse) at lower speeds, improved as speed increased, and eventually stabilized. No significant demographic differences were found between groups.

Conclusions

Worse foot placement control at low speeds supports earlier findings that slower gait requires less precise control. While healthy adults improve towards consistent ML foot placement control with increasing gait speed, paretic control worsens whereas non-paretic control remains consistent in PwCS at speeds exceeding CWS. **The increased** motor control deficits at higher gait speeds emphasizes the potential benefits of integrating speeds above CWS into training or therapy programs.

References

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[2] Wang, Y., & Srinivasan, M. (2014). *Biology letters* 10(9).

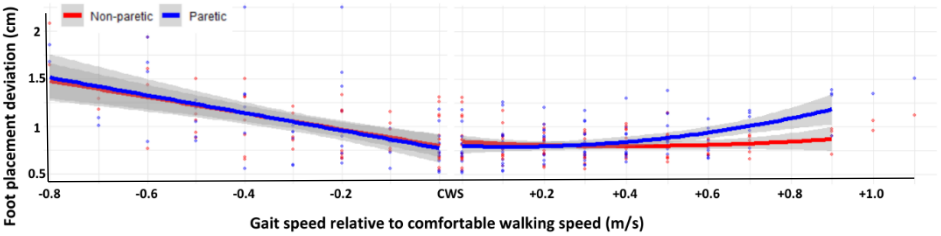

Figure 1. ML foot placement deviation for velocities below (left) and above (right) comfortable walking speed (CWS) in persons with chronic stroke (PwCS)