Relationship between prefrontal cortex activity and impaired balance after stroke

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Summary

Gait instability can result in falls during walking and limit independent function in community dwelling chronic stroke survivors. Limited independence in walking contributes to poor quality of life. Increase in prefrontal cortex (PFC) activity has the potential to compensate for impaired neural mechanisms of balance control after stroke, thereby improving balance performance. Our aim is to evaluate the relationship between PFC activity patterns during walking and clinical outcomes of balance in chronic stroke survivors.

Introduction

Impaired neural mechanisms involved in mobility and balance control after stroke lead to decline in balance performance during walking. In healthy individuals, an initial increase in prefrontal cortex (PFC) activity is typically followed by a reduction due to more automaticity and decline in demand for attentional resources during continuous walking at comfortable speeds[1]. However, in individuals with stroke, this reduction is much smaller likely due to constant need for cognitive attention as a consequence of impaired balance control[2]. The relationship between balance function and change in PFC activity patterns in different phases (early and late phases) during walking is not known.

Methods

All participants (n=10) first completed clinical assessments for balance including Berg Balance Scale (BBS), Activities-specific Balance Confidence (ABC) Scale, and Functional Gait Assessment (FGA). To evaluate PFC activity during walking using Functional near-infrared spectroscopy (fNIRS), we first determined the participant's self-selected comfortable walking speed on the treadmill. Following the speed determination, participants performed six trials 60 seconds each of walking. Each trial was preceded by 40s of quiet standing. Change in prefrontal oxygenated hemoglobin concentration between quiet standing and walking was used as the outcome measure of PFC activity, because continuous wave fNIRS measurements are relative and need to be adjusted by quite standing baseline values.

PFC activity in the early phase was defined as initial 30 sec, and late as final 30 sec of each walking trial. Reduced PFC activity while walking was defined as a negative value when subtracting the early phase from the late phase, while sustained PFC activity was defined as a positive value.

For further analysis participants were separated into two groups: reduced or sustained PFC activity. The Independent Samples t-Test was used for comparison between groups.

Results and Discussion

5 out of 10 individuals with chronic stroke had sustained PFC activity. Statistical analysis revealed slightly but significantly lower balance scores as measured by the BBS in the group with sustained PFC activity (p=0.028), 95% CI [-14.24, 0.25]. Although, not significant, ABC and FGA scores were lower in the sustained group (Table 1)

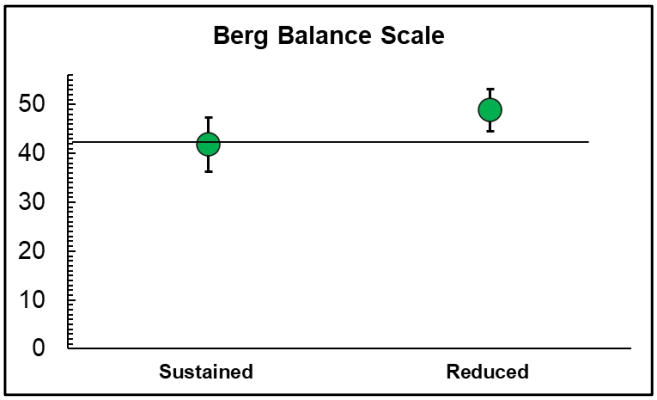

Figure 1: BBS scores were significantly lower in the group with sustained PFC activity, (black line indicates a BBS score of 42, predictor for falls in chronic stroke population).

Conclusions

This suggests that individuals with sustained PFC activity during typical walking are at greater risks of falls, however further analysis with a larger sample size and biomechanical measures of balance is needed to better understand the underlying mechanisms of balance control. Future studies are needed to investigate the potential of PFC as a neuromodulation target that can reduce fall rates after stroke.

References

[1] Baek CY et al. (2023). *JNER*, **20(1)**: 86.
[2] Hawkins KA et al. (2018). Hum. Mov. Sci, **59**: 46-55.

Table 1: Between group results for clinical outcome measures of balance.

Variable	BBS	ABC	FGA
(p-values; group means: [Sustained, Non-sustained])	(p=0.028; [41.8, 48.8])	(p=0.067; [55.75, 72.85])	(p=0.16; [15.4, 17.6])