FES-Induced Weight Transfer in Healthy Individuals: Insights for Stroke Rehabilitation

Ömer Kürşad Katırcı[1,2], Anthony M J Bull[1]
[1]Department of Bioengineering, Imperial College London, UK
[2]Department of Health Sciences, Afyonkarahisar Health Sciences University, Türkiye
Email: k.katirci22@imperial.ac.uk

Summary

This study evaluated the feasibility of functional electrical stimulation (FES) applied to the non-dominant side (nDms) gluteus medius in 14 healthy individuals to assess its impact on weight-bearing symmetry. Ground reaction forces (GRF) data were collected and analysed using MATLAB. Results showed a significant shift towards the dominant side (Dms) with FES, suggesting a possible avoidance response, differing from expectations in stroke patients.

Introduction

Stroke is a leading cause of mortality and disability worldwide, often affecting multiple physiological systems [1]. Impairments in muscle activation, pelvic stability, weight distribution, and lower limb transfers contribute to balance deficits, fall risk, and gait difficulties. Studies suggest that external lateral pelvic correction can enhance paretic-side muscle activation, weight transfer, and symmetry [2]. Such correction may be achieved using (FES) targeting the hip abductors. This feasibility study aims to assess the effects of FES applied to the gluteus medius in healthy individuals, focusing on weight transfer symmetry during walking as a precursor to future research involving stroke survivors.

Methods

This study involved 14 participants (7♂, 7♀; age: 27.7±3.7 years) tested under two conditions: with and without FES. Electrodes were placed on the gluteus medius of the nDms, using a 45 Hz asymmetrical biphasic waveform with a maximum current of 80 mA, set to elicit hip abduction without discomfort. Participants walked over force plates without speed constraints. GRF were collected at 1000 Hz using force plates (Kistler, Switzerland) and processed in MATLAB (The Mathworks Inc., USA).

Signals were converted to positive values and filtered with a fourth-order Butterworth (6 Hz) low-pass filter, and gait events were identified using a 30 N threshold. Peak GRF vertical component (vGRF) was found, and symmetry indexes were computed with (1), where X is the first peak of the vGRF. Normality was assessed via the Shapiro-Wilk test, and paired t-tests were conducted. Additionally, vGRF data were normalized to body weight, and statistical Parametric Mapping (SPM) was used to analyse time-series vGRF differences between conditions.

$$Directional\ SI = \left(\frac{vGRFXdominant - vGRFXnondominan}{0.5\times(vGRFXdominant - vGRFXnondominant)}\right)\times 100 \quad \textbf{(1)}$$

Results and Discussion

Without FES, there was no difference in vGRF between sides, but with FES, there was a small difference in the first peak (Figure 1) which resulted in a large change in the symmetry index (Table 1).

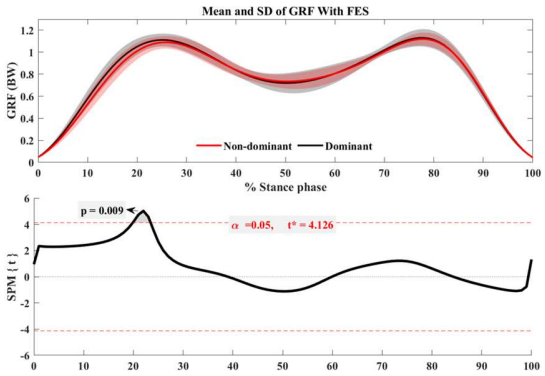

Figure 1: SPM graphs of vGRF in Dms and nDms with FES.

Test	Without FES	With FES	P-value
Symmetry index %	-1.85(4.96)	2.11(2.87)	0.023

Table 1: The effect of FES on Directional Symmetry Index (mean±SD)

In individuals with stroke, the weight was expected to be transferred to the side with FES, whereas the opposite occurred in healthy participants. This may be an avoidance movement due to the sensation caused by FES. It is unknown if this avoidance would be present in individuals with stroke.

Further work should include investigation of the other musculoskeletal effects of this weight transfer, including changes in muscle contraction on both Dms and nDMs using direct EMG measurement and indirect measurement using musculoskeletal modelling.

Conclusions

FES shifted weight toward the dominant side in healthy individuals, which is the opposite of the expected weight transfer in stroke patients.

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References

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