The kinematic effects of common peroneal Functional Electrical Stimulation (FES) in Chronic Stroke (CVA) and Multiple Sclerosis (MS) using a 3-D model of the shoe

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Introduction

Measurements of foot inversion/eversion during gait are of particular interest in people using common peroneal Functional Electrical Stimulation (FES). In addition to addressing excessive equinus in swing, FES systems are commonly prescribed to improve stability at initial contact and/or forefoot clearance in swing, in the presence of excess inversion. To date, the direct effects of FES on foot movement in 3-D have not been published, as available 3-D clinical foot models such as the Oxford Foot Model (Stebbins et al. 2006) require additional markers to be applied to the foot in an accurate manner, preventing their use when footwear is donned.

The aim of this project was to characterise gait kinematics with and without FES in 3-D for existing FES users at Sheffield Teaching Hospitals (STH) gait laboratory, using an in-house developed ‘shoe model’. In addition to the standard Vicon PlugIn Gait (PiG) marker set, this model required additional markers on the medial and lateral aspect of the distal first and fifth metatarsal heads respectively. It was preliminary validated through comparison of outputs from barefoot kinematic data processed with the Oxford Foot Model, from the normal database available at Sheffield Childrens Hospital (SCH) gait laboratory.

Patients/ Material and methods

Data with footwear was collected using 8 Vicon MXF40 cameras (Vicon Ltd, Oxford UK) capturing at 100Hz from existing unilateral FES users at STH (n=20, n=9 CVA, n=11 MS). The electrode sites and the pulse width were selected by the patient to reflect their usual response. Patients walked at self-selected normal speed, until two representative traverses were completed with both FES on and off (randomised order). For both MS and CVA groups, the non-parametric Wilcoxon test (level of significance p ≤ 0.05) was calculated to investigate the null hypotheses of no difference with or without stimulation at the following events: DF/PF at initial contact and maximum DF in swing for all subjects; inversion/eversion at initial contact and inversion/eversion in mid-swing, for subjects with shoe model data.

Results

Figure 1. No FES (dashed) v FES (solid) v normal adult barefoot data (grey).
Median speed (25th-75th percentile) was calculated from 3D data: MS (n=11) = 0.60m/s (0.37-0.96) without FES, 0.63m/s (0.52-1.10) with FES; CVA (n=9) = 0.70m/s (0.41-0.80) without FES, 0.74m/s (0.63-0.90) with FES. At the events chosen, all differences were found to be statistically significant with the exception of coronal plane movements in the CVA population.

**Discussion & Conclusion**

Direct improvements in 3-D kinematics were found with FES applied, with increased dorsiflexion and reduced inversion during swing and at initial contact, therefore improving ground clearance and pre-positioning of the foot. Improvements in the coronal plane were only statistically significant for MS patients, perhaps due to the variable and often increased tone seen in the CVA population. The ‘shoe model’ was practical to use in a clinical environment.

**References**