CLINICAL VALIDATION OF STATIC OPTIMIZATION DURING POST STROKE GAIT

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Introduction

Post stroke gait is characterized by muscle impairments leading to abnormal gait patterns and muscle function. Knowledge of individual muscle forces would facilitate rehabilitation and inform targeted exercise programs. However, they cannot be obtained, rather calculated from musculoskeletal modeling, based on motion capture and inverse dynamics approaches. Validation of different optimization algorithms has been limited on healthy populations, mostly because generic MSK models do not include patient-specific pathologies. Different methods have been proposed to address this, all of them being difficult to apply in a clinical setting [1]. Thus, the aim of this study is to, for the first time, validate muscle activations as calculated from less-demanding, easy-to-use and computationally cheap static optimization (SO) against synchronous electromyography (EMG) data during post stroke gait.

Methods

Three chronic stroke patients (1 male, mean (std) age: 57 (10) years), were recruited from a database of the General Hospital of Komotini, Thrace, Greece. Three-dimensional motion capture (10 cameras, Vicon) and two ground-embedded force plates (Kistler) were used to record position-time data during overground walking and ground reaction forces, sampling at 100 and 1000 Hz respectively. Five successful trials from each leg were used for further analysis. A generic full body musculoskeletal model [2] was linearly scaled to each patient based on a static trial and individual mass. Joint angles and muscle activations for both sides were calculated using the inverse kinematics Tool, and SO analyses in Opensim respectively, during stance phase. Bilateral surface EMG (Noraxon, USA) was collected at 2000 Hz on Tibialis Anterior (TA), Peroneus Longus (PL), Soleus (SOL), Gastrocnemius Lateralis (GL), Gluteus Maximus (GMAX), Gluteus Medius (GMED), Biceps Femoris Long Head (BFLH), Semiteninodus (SEM), Tensor fasciae latae (TFL), Vastus Lateralis (VL), Vastus Medialis (VM) and Rectus Femoris (RF) of both paretic and non-paretic side. EMG data were bandpass filtered at 30-300 hz, rectified and low-pass filtered at 6 Hz. To align order of magnitudes between SO and EMG, the latter was normalized to the peak of individual gait cycle and multiplied to peak of correspondent SO data. Similarity between SO and EMG was quantified with cosine similarity and root mean square error (RMSE) metrics. A COS closer to 1 indicates better agreement in activation timing between the two curves.

Results

For the paretic side, higher COS and lowest RMSE values were calculated for most muscles except TA, RF, TFL with the exception of GMED (highest RMSE). For the non-paretic side, higher COS and lowest RMSE values were calculated for most muscles except TA, RF and VL, with the exception of GMED and SOL (highest RMSE).

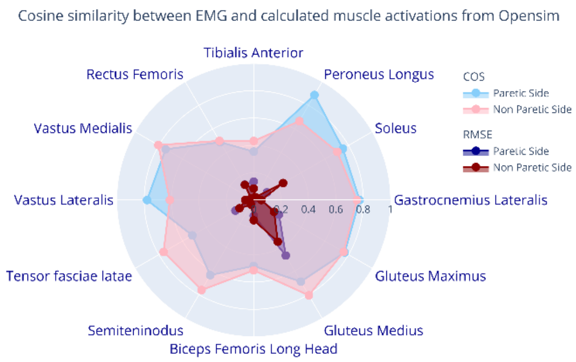

Figure 1: Mean COS and RMSE values for all muscles across subjects for both sides (blue: paretic, red: non-paretic).

Discussion

The current study showcases the strength of Static Optimization to calculate main muscle activations of lower limb in an acceptable accuracy for post stroke patients with a hemiparetic side. Our results show comparable agreement between EMG and SO to healthy data [3], with the exception of TA. The latter has showed activation throughout the stance phase, especially in the paretic side, which was not present in the calculated data from SO (activation only during early stance). In the case of RF and BFLH, low COS values for both sides are mainly due to different activation timings between EMG and SO, with the latter failing to estimate coactivation of both muscles as evident in EMG data. Future work will include more patients with different mobility profiles.

References

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