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The importance of the use of electromyography in neuromusculoskeletal modelling

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Short communication

O 037 – Estimating musculotendon forces in children with cerebral palsy: The importance of the use of electromyography in neuromusculoskeletal modelling

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1. Introduction

Computational modelling of the neuromusculoskeletal system (NMSS) can potentially provide detailed insight into muscle function to optimize treatment planning and evaluation in cerebral palsy (CP). Commonly, static optimization is used to solve the redundancy problem in estimating muscle forces, assuming, for example, minimization of the muscle activation squared. However, since the primary problem in children with CP is an aberrant motor control [1], it is questionable if using this criterion is applicable in this clinical population. Electromyography (EMG) might be used to further inform optimization procedures and improve model performance.

2. Research question

What is gained in using EMG-based NMSS modelling to estimate muscle activations during gait in children with CP compared to static optimization?

3. Methods

Five patients with CP participated (11.4 ± 2.7 y, GMFCS I–II). Each patient walked on an instrumented treadmill at comfortable self-selected walking speed, while marker trajectories, ground reaction forces and EMG of eight lower limb muscles were recorded. OpenSim [2] was used to scale a generic model to the lengths of the patients' segments, using static pose data. Inverse kinematics and inverse dynamics were applied on this model for four randomly selected strides. Four different modeling approaches were used to estimate musculotendon forces. The first two approaches used the static optimization tool in OpenSim to estimate muscle forces, either directly (SO), or after scaling the maximum isometric force of each muscle to body mass (SO_MIF). The third (EA_uncal) and fourth (EA_cal) approach used EMG-assisted modelling, combining EMG data with static optimization (CEINMS software [3]). In EA_cal musculotendon parameters were first calibrated to optimize the matching of EMG-driven moments with inverse dynamics moments [4]. To examine each model's performance, predicted activations were correlated to activations derived from EMG, and predicted joint moments were correlated to those estimated using inverse dynamics. Correlations were quantified by R^2, and compared between approaches with repeated measures ANOVA.

4. Results

Scaling the maximum isometric force did not significantly improve the R^2 for the model's activations with EMG activations (Fig. 1A). Using an EMG-assisted approach improved the R^2, but not significantly for EA_uncal. EA_cal showed a significantly higher R^2 vs. SO ($p = 0.050$) and EA_uncal ($p = 0.022$). Using both EMG-assisted approaches only slightly decreased the tracking of inverse dynamics moments (Fig. 1B), without any significant differences.

5. Discussion

This study shows that static optimization is not a valid approach to estimate musculotendon forces in CP. Alternatively, using an EMG-assisted approach provides a relevant physiologically more correct solution, especially after calibration of musculotendon parameters. Therefore, it is suggested to use a calibrated EMG-assisted approach rather than static optimization when estimating musculotendon forces in CP. Further personalization of the model is advised to further improve the model performance.

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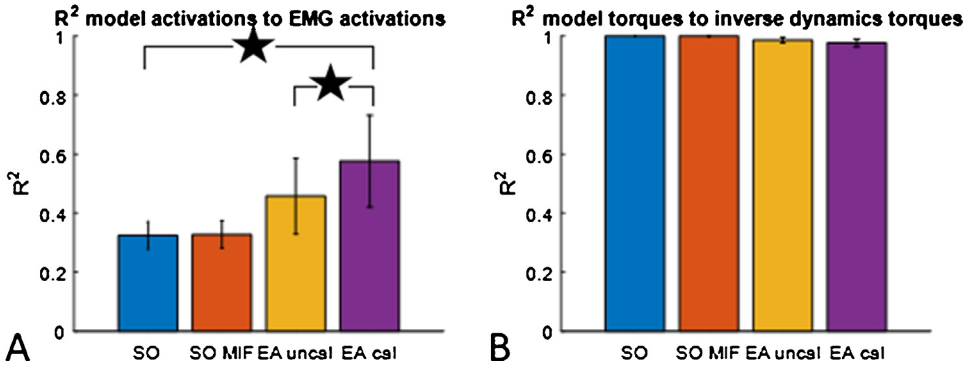

Fig. 1. Figure 1A shows the R^2 of the activations of each model compared to the EMG activations. Using a static optimization approach (SO) showed a low agreement with EMG activations, which was higher when an EMG-assisted (EA) approach was used, especially when the model had been calibrated. Figure 1B shows that the inverse dynamics joint moments were tracked well in all approaches.

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