

A NOVEL APPROACH FOR QUANTITATIVE MUSCULOSKELETAL ASSESSMENT IN POST-STROKE REHABILITATION

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Introduction

Assessing post-stroke gait recovery is a key goal in rehabilitation. Clinics typically use observational gait assessments [1] and 3D gait analysis to evaluate motor impairment. These methods have limitations, such as subjectivity and the need for expensive equipment and time-consuming setup. Additionally, current clinical assessments do not provide quantitative metrics on muscle strength and forces and how they affect gait over time. Neuromusculoskeletal (NMS) models [2] in equipped gait labs can provide objective evidence of a patient's musculoskeletal function. However, the need for expensive equipment and manual sensor placement makes it not practical for clinical use. We developed a technology that includes a modular 64 textile-embedded EMG leg garment, an automated EMG clustering algorithm for quickly locating leg muscles, and an EMG-driven NMS model for estimating muscle-specific activation, ankle muscle-tendon forces, and torques during walking for post-stroke individuals.

Methods

For the study, seven individuals who had experienced hemiparetic strokes were recruited from the Sint Maartenskliniek in the Netherlands. The study involved recording EMG, kinetic, and kinematic data while the participants walked at a self-selected comfortable, and faster speed. A 64-channel EMG grid was embedded in a stretchable garment and applied to the affected leg. The 64 electrodes were then grouped into specific muscle clusters using a two-step non-negative matrix factorization (NNMF) algorithm. The average muscle activation was calculated for both speeds and input into an EMG-driven NMS model to estimate ankle torque. The estimated torque was then compared to experimental torque and torque estimated through manually selected EMG-driven NMS modeling.

Results and discussion

The study found that the NNMF-based EMG clustering method was effective in identifying the location of main leg muscles by analyzing 64-electrode activations during three gait cycles at a comfortable speed. The automatically derived muscle-specific clusters lead to consistent muscle-specific envelopes during both walking speeds. Additionally, the muscle-specific EMG envelopes had sufficient accuracy to drive the NMS model and estimate ankle torques during gait for post-stroke individuals. As a representative example, Figure 1 shows the results of EMG (Figure 1.A) and estimated torque (Figure 1.B) for comfortable walking.

Conclusion

The use of automatic NNMF-based EMG clustering and NMS models enables fast and quantitative assessment of musculoskeletal function in post-stroke individuals. It has the potential to be applied to other injured populations as well for efficient and accurate assessment of gait recovery in the clinical setting.

References

- [1] Mehrholz J. et al, *Arch. Phys. Med. Rehabil.*, 88: 1314–1319, 2007.
- [2] Durandau G. et al., *IEEE Trans. Biomed. Eng.*, 65: 556–564, 2018.

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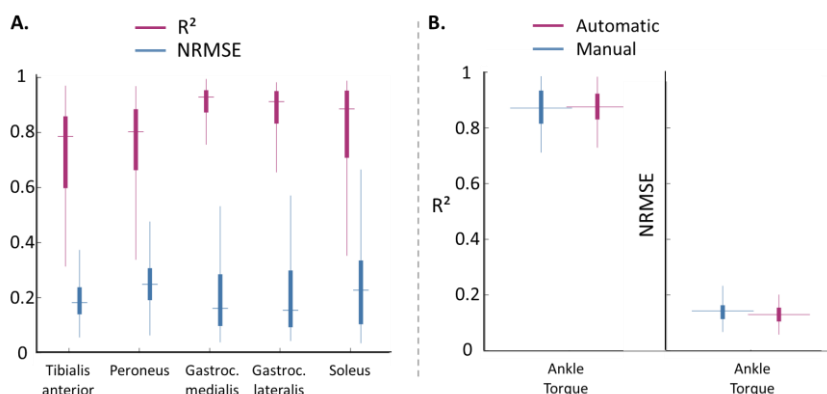


Figure 1: A. Box plots displaying the distribution of R^2 (red) and NRMSE (blue) values computed between manually and automatically derived EMG envelopes of each muscle, across all subjects and gait cycles during comfortable walking. B. Distribution of R^2 and NRMSE values computed between experimental torque, and manually (blue) and automatically (red) derived EMG-driven ankle torque estimates, across all subjects and gait cycles at comfortable walking.

