

MINIMUM VIABLE MUSCLE SET FOR IDENTIFYING IMPAIRMENTS IN THE NEUROMUSCULAR CONTROL OF WALKING USING THE DYNAMIC MOTOR CONTROL INDEX

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Introduction

When used to quantify co-activity of eleven lower-limb muscles during walking, the dynamic motor control index has potential as a biomarker of age-related neuromuscular impairment¹. Clinical applications of electromyography typically examine fewer muscles², thus using a reduced muscle set may facilitate clinical translation of the dynamic motor control index. However, the composition of the muscle set may impact its measurements.

Eight- and five-muscle sets have been used to measure differences in neuromuscular control between those with versus without cerebral palsy^{2,3}. It is unknown if these reduced muscle sets can identify the age-related neuromuscular differences that we previously identified using an eleven-muscle set. The primary aim of this study was to test if dynamic motor control indices generated using eleven-, eight-, and five-muscle sets would similarly differentiate age subgroups (Fig. 1). In an exploratory study, we extended our examination to walking after stroke.

Methods

Electromyography data were collected during treadmill walking from 36 neurotypical adults, separated into young (N=18, <35 yrs), young-old (N=13, 65-74 yrs), and old-old (N=5, >= 75 yrs) subgroups, and 3 individuals post-stroke. Using eleven¹, eight² and five lower-limb muscle³ sets (Fig 1A), non-negative matrix factorization was used to calculate the dynamic motor control index for each participant¹ (Fig 1 B-C), with a score of 100 representing neuromuscular performance of the young adult group. Multinomial logistic regression was then used to evaluate if dynamic motor control indices computed using the reduced muscle sets could differentiate between age subgroups. As previously described¹, the number of muscle synergies—a common alternative measure of neuromuscular control—was also computed for each individual and added to each model as a covariate. With only 3 participants in the post-stroke group, the trends within and across individuals are discussed.

Results and Discussion

To differentiate across age-related subgroups, regression models using the eleven ($\chi^2(4)=10.62$, $p=0.031$, Nagelkerke $R^2=0.297$) and eight ($\chi^2(4)=9.418$, $p=0.051$, Nagelkerke $R^2=0.267$) muscle sets were significant and approaching significance, respectively, whereas the model for the five-muscle set was not significant ($p=0.663$). In both the eleven (Wald $\chi^2=5.16$, $p=0.023$, OR=1.26) and eight-muscle set models (Wald $\chi^2=4.20$, $p=0.04$, OR=1.19), after controlling for the number of synergies, a higher dynamic motor control index was significantly predictive of being in the young group compared to the old-old group.

In the post-stroke group, dynamic motor control indices for the paretic limb of all 3 participants were less than their age-matched control group (young-old), regardless of the muscle set used. The eleven-muscle set allowed differentiation between paretic and non-paretic limbs for P1 and P2, while P3 showed significant bilateral impairment. Using the eight-muscle set, the dynamic motor control indices for the paretic limbs of P1 and P2, and both limbs of P3, were unchanged, while the indices for the non-paretic limbs of P1 and P2 decreased. For all 3 participants,

indices with the five-muscle set were notably different than the eleven-muscle set. This suggests that the muscles removed may be of high importance for identifying post-stroke impairments. Alternatively, it is possible that with fewer muscles, the dynamic motor control index calculation may be impacted by higher variability in the electromyography data of a single muscle.

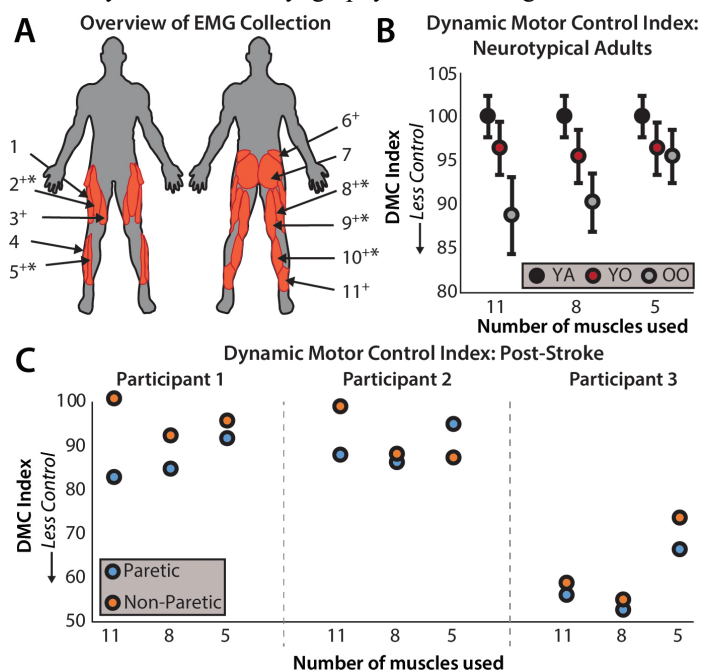


Figure 1: A) Overview of 11, 8+, and 5* muscle sets. Muscles (in order): vastus lateralis, rectus femoris, vastus medialis, peroneus longus, tibialis anterior, gluteus medius, gluteus maximus, biceps femoris, medial hamstrings, medial gastrocnemius, and soleus. B) The dynamic motor control index differentiates age groups with the 11- and 8-muscle sets, but not the 5-muscle set. Mean \pm SE. C) The 11- and 8-muscle sets may be able to identify neuromuscular impairments post-stroke.

Significance

Age-related differences in the neuromuscular control of walking can be detected using dynamic motor control indices generated using the eleven- and eight-muscle sets studied, but not the five-muscle set. This interpretation is limited by the small sample size in the old-old subgroup. Similarly, the eight-muscle set may be the minimum for identifying neuromuscular impairments after stroke. These findings contrast with prior work that successfully used the five-muscle set to detect differences due to cerebral palsy³. Alternative five-muscle sets or tasks that amplify the neuromuscular differences should be investigated.

Acknowledgments

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References

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