

QUANTIFICATION OF MUSCULAR CHALLENGE DURING OBSTACLE CROSSING IN THE ELDERLY: EMG vs. JOINT MOMENT

Li-Shan Chou, Heng-Ju Lee, and Michael E. Hahn

Motion Analysis Laboratory, Department of Exercise and Movement Science
University of Oregon, Eugene, Oregon, U.S.A
E-mail: chou@uoregon.edu

INTRODUCTION

Skeletal muscle strength involved in postural control and locomotion is known to decline with age and disease (Fiatarone and Evans, 1993). It is important to be able to quantify the relationship between muscular demands and gait/balance deviations in the elderly. To better examine the level of challenge imposed on a muscle group, a quantitative index is needed to take into account both strength capacity and strength requirement during performance.

Studies used the ratio of peak calculated joint moments required during activities of daily living (ADL) to peak measured dynamometric torques during maximum voluntary contractions (MVC) and found that older adults required a significantly higher fraction of measured MVC torque in the lower extremity than young adults to perform a majority of the ADLs (Hortobagyi et al., 2003). It should be noted that joint moments computed through inverse dynamics only indicate the net moment from all muscular effort, which provides little information on the level of mechanical demand imposed on an individual muscle group.

Dynamic EMG data allows us to examine the timing and relative intensity of the muscle effort (Perry, 1993). The ratio between the EMG amplitudes collected during functional tasks and the peak EMG amplitude collected during the maximum effort manual muscle testing (MMT) can be used to quantitatively identify the utility of available strength of a

muscle group. The purpose of this study was to evaluate and compare two muscular activating ratios, defined by EMG and net joint moment, of selective lower extremity muscles between young and elderly adults during level walking and while crossing an obstacle.

METHODS

Eleven young adults (6 males/5 females; mean age 24.8 yrs) and sixteen elderly adults (8 males/8 females; mean age 71.3 yrs) were recruited for this study. All participants were determined to be free of neuromuscular or orthopedic pathologies.

Pre-amplified surface electrodes were attached bilaterally to bellies of the gluteus medius (GM), vastus lateralis (VL) and gastrocnemius (medial head, GA). Maximum effort MMT was performed for isometric hip abduction, knee extension, and ankle plantar flexion. EMG signals were collected at 960Hz using the MA-300™ system (Motion Lab Systems, Baton Rouge, LA). MVC tests were performed with a KinCom dynamometer (Chattecx, Hixson, TN) on hip abductors, knee extensors, and ankle plantar flexors. Subjects were then asked to walk at a self-selected pace with barefoot during unobstructed level walking and when stepping over an obstacle of height corresponding to 2.5%, 5%, 10%, or 15% of the subject's height. The order of obstacle height was randomly selected. Motion analysis was performed with a 6-camera ExpertVision™ system (Motion Analysis Corp., Santa Rosa, CA). Two

force plates (AMTI, Watertown, MA) were used to collect ground reaction forces with a sampling rate at 960 Hz.

Filtered EMG signals from gait trials were normalized to the MMT signal maximum for each muscle to indicate relative activation levels. OrthoTrak software (Motion Analysis Corp., Santa Rosa, CA) was used to calculate joint moments of both limbs during the crossing stride. Similarly, peak joint moments were normalized to the maximum joint moment collected from MVC to derive relative activation levels. Normalized EMG (N-EMG) and joint moment (N-moment) ratios were analyzed for the effects of age group and obstacle height with a two-factor ANOVA with repeated measures.

RESULTS AND DISCUSSION

Compared to young adults, elderly adults demonstrated significantly higher N-EMG ratios in the VL and GM of both limbs ($p < 0.05$). Similarly, elderly adults also showed significantly greater N-joint moment ratios in hip abductors and ankle plantar flexors of both limbs ($p < 0.05$) than young adults. However, young adults demonstrated significantly greater N-moment ratios in knee extensors of both limbs than elderly adults ($p < 0.05$; Fig. 1).

Increasing obstacle height resulted in significantly greater N-EMG ratios for all muscles of both limbs in all subjects ($p < 0.05$), except for the trailing limb VL of elderly adults. Significant obstacle height effects on N-moment ratios were only detected for the trailing hip abductor and leading knee extensor ($p < 0.05$).

The opposite trend found between the VL N-EMG and knee extensor N-moment of the leading limb could be interpreted as although the net knee joint moment decreases with higher obstacles, greater co-activations of both agonist and antagonist

muscles are required. This indicates that N-EMG ratios may be better to truly quantifying the level of challenge imposed on a muscle group.

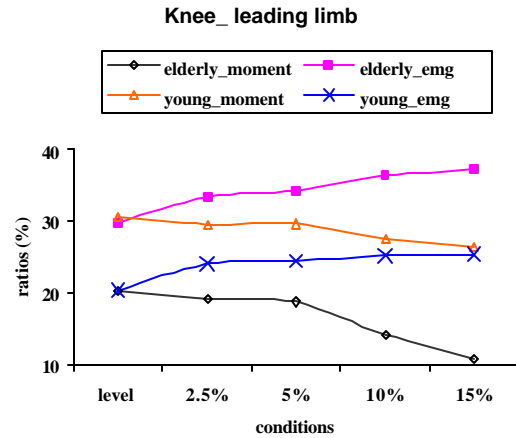


Figure 1. N-EMG ratios of the VL and N-moment ratios of the knee extensor of the leading limb.

SUMMARY

Elderly adults required significantly greater relative activation levels, compared to young adults, to successfully negotiate an obstacle during gait. N-EMG ratios might allow us to better quantify muscular challenge and to assess the relationship between muscular demands and gait/balance deviations in the elderly.

REFERENCES

- Fiatarone and Evans (1993), *J Gerontol* **48S**, 77-83.
- Hortobagyi et al. (2003), *J Gerontol* **58A**, 453-460.
- Perry, J. (1993) *Gait Analysis*. Thorofare, NJ, Slack Inc.

ACKNOWLEDGEMENTS

This study was supported by the NIH (AG 022204-01; HD 042039-01A1). Assistance from Jung-Hung Chien in data reduction is greatly appreciated.