IDENTIFYING MUSCULAR CHALLENGE DURING LOCOMOTION IN THE ELDERLY: AN EMG STUDY

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INTRODUCTION

Adequate muscle strength in the lower extremities is essential for effective responses to maintain balance during locomotion. However, skeletal muscle strength declines with age (Fiatarone et al., 1993). Age-related reductions in strength are greatest in the lower extremity muscles (McDonagh et al., 1984) and may limit functional ability and contribute to falls in the elderly.

To better examine the level of challenge imposed on a muscle group, a quantitative index that takes both the strength availability (capacity) and strength requirement (demand) during performance into account is needed. Dynamic EMG data allows us to examine the timing and relative intensity of the muscle effort (Perry, 1993). Difference in the EMG magnitude of a single muscle represents varying levels of effort. 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, which can allow us not only to monitor muscle recruitments during different phases of gait but also to examine the instantaneous level of neuromuscular challenge imposed on the selected muscle. Thus, the purpose of this study was to test the hypothesis that this EMG ratio is able to quantitatively reflect a relatively higher challenge in lower extremity muscles of elderly adults when compared to young adults during balance challenging tasks, such as obstacle crossing.

METHODS

Ten young adults (5 males/5 females; mean age 25.2yrs) and twelve elderly adults (8 males/4 females; mean age 72.7yrs) 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). These muscle groups were previously shown to be substantially challenged during obstacle crossing (Chou et al., 1998). Maximum effort MMT was performed for isometric hip abduction, knee extension, and ankle plantar flexion. Subjects were then asked to walk at a self-selected pace during level and obstructed gait tasks. A light-weight crossbar was set to a single obstacle as height of 2.5, 5, 10, and 15% body height (BH). Obstacle heights were randomized with 3 trials being collected for each condition. Data were analyzed from the heel-strike of the trailing limb before stepping over the obstacle to its next heel-strike when crossing the obstacle (i.e., cross stride). The leading limb was defined as the first limb to cross the obstacle followed by the trailing limb.

EMG signals were collected at 960Hz using the MA-300™ system (Motion Lab Systems, Baton Rouge, LA). Filtered and rectified signals from the gait trials (demand) were then normalized to the MMT
signal maximum (capacity) for each muscle to indicate their relative activation levels. The crossing stride was divided into 4 phases according to the trailing limb: 1st double support, 1st single support, 2nd double support, and swing phases. Similarly 4 phases were defined for the leading limb: swing, 1st double support, single support, 2nd double support. Mean EMG ratios of both limbs during each phase were then analyzed for the effects of age group and obstacle heights with a two-factor ANOVA with repeated measures of obstacle height.

RESULTS AND DISCUSSION

Compared to young adults, elderly adults demonstrated greater relative activation levels in both lower limbs for all four phases. Average EMG ratios of GM and VL were significantly greater in the elderly (p=0.039 and p=0.031, respectively) and were activated up to 50% and 40% of their peak MMT magnitudes, as compared to 30% and 25% in the young (Fig. 1). The GA of the elderly was activated up to 43% of its peak MMT magnitude, as compared to 36% in the young.

Each of obstacle crossing condition required greater activation levels than level walking for all muscles of both lower limbs. Increasing obstacle height resulted in significantly greater relative activation for all muscles of both limbs (p=0.023). Peak relative activation of GM and VL of both limbs occurred during the 1st double-support phase (weight acceptance). The results can be interpreted as during double-support, weight transfer and acceptance required GM to maintain medio-lateral balance and VL to maintain anterior balance. The GA peak mean relative activation occurred at single-support phase. Maintenance of dynamic stability and forward progression is required during the single-support phase of gait.

SUMMARY

Findings from this study indicated that elderly adults require a greater proportion of their muscular capacity during level walking and obstacle crossing tasks than young adults. As the task of crossing obstacles poses a greater challenge to dynamic balance control, it may be inferred that decreased lower extremity muscle strength likely puts the elderly population at greater risk for imbalance or falling. This EMG ratio may further allow us to better identify the timing for the onset of falls (maximum instability) in the elderly.

REFERENCES


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