INTRODUCTION

Skeletal muscle strength is known to decline with age (Fiatarone, 1993). As an intrinsic risk factor contributing to falls, lower extremity (LE) muscle strength is a critical component in limiting an elderly individual’s dynamic stability (Buchner, 1991; Brown, 1995). It has been reported that fallers demonstrated only 37% of the knee extensor strength, and 10% of the ankle plantar flexor strength exhibited by their non-falling peers (Whipple, 1987). Although these findings infer that muscular weakness contributes to falling, only one study has reported the relative challenges posed to LE musculature during activities of daily living (Bus, 2001). The purpose of this study was to investigate the effects of age and obstacle crossing on relative neuromuscular challenge. It was hypothesized that healthy elderly adults would require a greater proportion of their neuromuscular capacity during level walking and while crossing obstacles.

METHODS

Nine young adults (4 male / 5 female; 25.3yrs, 170.1cm, 72.8kg) and six elderly adults (4 male / 2 female; 70.3yrs, 171.3cm, 78.1kg) were recruited for this study within the guidelines of the University I.R.B. All participants were determined to be free of neuromuscular or orthopedic pathologies. Pre-amplified surface electrodes were fixed bilaterally over the bellies of the gluteus medius (GM), vastus lateralis (VL) and gastrocnemius (GA), medial head. These muscle groups were previously shown to be substantially challenged during obstacle crossing (Chou, 1998). Maximal manual muscle testing (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 single obstacle consisting of two upright standards and a light-weight crossbar was set to a height of 2.5, 5, 10, and 15% body height (BH). Obstacle heights were randomized with 3 trials being collected for each condition. The leading limb was defined as the first limb to cross the obstacle, with the trailing limb following.

For all MMT and gait trials, raw EMG signals were collected at 960Hz using the MA-300™ system (Motion Lab Systems, Baton Rouge, LA), band-pass filtered (20-350Hz), full wave rectified, and passed through a linear envelope at 10Hz for final interpretation. Filtered signals from the gait trials (demand) were then normalized to the MMT signal maximum (capacity) for each muscle to indicate relative activation levels. The mean value for each support phase in the gait cycle (double-support & single support, bilaterally), was recorded for the leading and trailing limb. These parameters were then analyzed for the effects of age group and obstacle height (two-factor ANOVA with repeated measures of obstacle height).

RESULTS AND DISCUSSION

Healthy elderly adults showed greater relative activation levels in the leading and trailing limbs, compared to young adults. For the trailing limb, there was an age effect on the normalized activation levels of the GM (p=0.043) and VL (p=0.003), but not the GA (p=0.082). In the leading limb, significant age effect was found for the GM (p=0.021), VL (p=0.014) and GA (p=0.008). Increased obstacle height resulted in greater relative activation of all muscles of both the leading and trailing limb (p<0.001).

During double-support, weight transfer and acceptance occurs laterally as well as anteriorly. In this phase, the GM and VL of the healthy elderly were activated up to 50% of their maximum capacity, as compared to 30% in the young. Maintenance of dynamic stability and forward progression is required during the single-support phase of gait. When the healthy elderly were in the single-support swing phase, GA activity also reached 50% of maximum, while the young required ~35% of their capacity.

SUMMARY

These results indicate that healthy elderly adults do require a greater proportion of their neuromuscular 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 LE strength likely puts the elderly population at greater risk for falls due to general dynamic instability or tripping. We theorize that a relative low-end threshold exists for LE strength, so that if an elderly individual weakens beyond the threshold, they will be at critically high risk for experiencing falls (i.e. fallers reported by Whipple, 1987). A model of relative risk estimation is being developed to allow individual risk assessment, given current LE muscular strength conditions.

REFERENCES


ACKNOWLEDGEMENTS

This work was supported by the ISB Dissertation Matching Grant and the Oregon Medical Research Foundation.