DOES AGE AFFECT LEG MUSCLE ACTIVITY/COACTIVITY DURING UPHILL AND DOWNHILL WALKING?

Jason R. Franz and Rodger Kram
Dept. of Integrative Physiology, University of Colorado, Boulder, CO, USA, jason.franz@colorado.edu

INTRODUCTION
Advancing age brings prominent changes in leg muscle activities during level-ground walking. Even healthy old adults disproportionately recruit hip extensor muscles during the stance phase. Some have questioned how much of this redistribution in muscle recruitment can be attributed to modified neural function vs. muscular weakness [1,2]. We reasoned that due to the greater concentric demand on leg extensor muscles during the stance phase, uphill walking would exacerbate hip extensor muscle reliance in old adults. If so, this would provide insight into the mechanisms responsible for the redistribution of leg muscle recruitment with advancing age. Compared to young adults, we hypothesized that old adults would exhibit greater increases in hip extensor muscle activities and smaller increases in ankle extensor muscle activities during uphill vs. level walking. We also sought to describe how uphill and downhill walking affect age-related increases in antagonist leg muscle coactivation [3].

METHODS
10 healthy young (25 ± 4 yrs) and 10 healthy old (72 ± 5 yrs) adults walked at 1.25 m/s on a motorized treadmill at seven grades (0, ±3, ±6, ±9°). Old subjects were exceptionally fit, recruited from local mountain hiking and cycling groups. We recorded electromyographic (EMG) signals from seven right leg muscles: tibialis anterior (TA), medial gastrocnemius (MG), soleus (SOL), vastus medialis (VM), rectus femoris (RF), biceps femoris (BF), and gluteus maximus (GMAX). We normalized the full-wave rectified EMG signals by two methods: 1) to their mean amplitudes during level walking and 2) to maximum isometric voluntary contractions (MVC). We computed average EMG amplitudes from heelstrike to midstance for VM, RF, BF, and GMAX and from midstance to toe-off for MG and SOL, corresponding to the primary stance phase EMG bursts. We then used methods introduced by Falconer and Winter [4] to calculate coactivation indices (CI) of agonist-antagonist muscle pairs of the thigh and lower leg.

RESULTS
Healthy young and old adults all employed the same general muscle recruitment strategies during uphill walking (greater recruitment of hip, knee, and ankle extensors) and downhill walking (only greater recruitment of knee extensors) (grade, p<0.01). However, as hypothesized, old adults exhibited smaller increases in MG activity with steeper uphill grade than young adults (age, p=0.02) (Fig. 1). Compared to level walking, MG activity increased by 136% to walk up 9° in old adults but by 174% in young adults. In compensation, old adults exhibited greater GMAX activity at all grades and approached their maximum isometric capacity at steep uphill grades (age, p=0.01). Compared to young adults, old adults exhibited greater coactivation of lower leg antagonist muscle pairs at all grades (CI_{MG,T} and CI_{SOL,T}) (age, p<0.05). But, young and old adults had similar coactivation of antagonist thigh muscle pairs (p=0.10). Coactivation of antagonist lower leg muscle pairs increased significantly with steeper downhill grade, but similarly in young and old adults (grade, p<0.01).

DISCUSSION AND CONCLUSIONS
Uphill walking exacerbates the disproportionate recruitment of hip extensor muscles that occurs with advancing age. Consequently, GMAX activity approaches the maximum isometric capacity of old adults at steep uphill grades. However, these exceptionally active old adults were still able to considerably increase ankle extensor muscle activity to walk up 9° compared to level walking. Thus, ankle extensor muscle weakness is unlikely the primary mechanism underlying the distal to proximal redistribution of leg muscle recruitment with advancing age. Many suggest that old adults utilize antagonist coactivation to increase joint stiffness [e.g., 3]. If so, then our results also imply that neither uphill nor downhill walking affect age-related increases in leg joint stiffness. We conclude that hip extensor muscle reliance may ultimately limit uphill walking ability and impair the independence of old adults.

REFERENCES

ACKNOWLEDGEMENTS
Supported by NIH (5T32AG000279) and a student Grant-in-Aid from the American Society of Biomechanics.