ANTICIPATION OF SLIPPERY FLOORS: MUSCLE ONSETS AND CO-CONTRACTION OF THE STANCE LEG

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INTRODUCTION

Falls are a major cause of injury, death and disability in the elderly [4,6,8]. In relatively healthy older adults, falls are often precipitated by base of support (BOS) perturbations such as slips and trips [1,5,6]. The use of proactive strategies has been revealed in gait studies using testing paradigms involving repeated exposure to a known perturbation [2,3]. The goal of this study, which has not been previously addressed, is to investigate the impact of anticipating real slippery floors on the muscle activity (onset and co-contractions) in the leading/left leg during gait on dry surfaces.

METHODS

Eleven young (20-33 yrs) and 9 older subjects (55-66 yrs), screened for neurological and orthopedic abnormalities, were instructed to walk at a self-selected pace across a vinyl tile walkway, while ground reaction forces and whole body motion were sampled at 1080 and 120 Hz, respectively. Also, EMGs were collected from the vastus lateralis (VL), medial hamstring (MH), tibialis anterior (TA), and medial gastrocnemius (MG) at 1080 Hz. Subjects were informed the first few trials would be dry, 'baseline dry' (BD). Without the subjects' knowledge, a glycerol solution was applied at the left/leading foot-floor interface, generating an 'unexpected slip. Subjects were then alerted that all remaining trials might be slippery, 'alert dry' (AD). Only the EMG data of the first 2 trials in the BD and AD conditions were analyzed here to minimize adaptation effects.

EMGs were rectified, low-pass filtered at 50 Hz using a zero-phase elliptical filter, and time normalized with respect to stance time (left foot) with 0% = Heel contact (HC) and 100% - Toe off (TO). The magnitude of the resulting EMG envelope was normalized within subject to the average peak value collected in the BD trials. Onsets were determined using a threshold of two standard deviations above baseline activity (with visual confirmation). A co-contraction index (CCI) was calculated based on the integrated (from -20% to HC and from HC to 20% into stance) ratio of the EMG activity of antagonist/agonist muscle pairs (TA/MG and VL/MH) using the equation proposed by Rudolph [7]. Within subject repeated measures ANOVAs were conducted on the onset, ankle and knee CCI using age (young/older), condition (BD/AD), and their interaction effect as independent variables. Significance level was set at 0.05

RESULTS

In general (exception is TA), muscle onsets were significantly affected by condition (Table 1). Specifically, the MG and MH were activated earlier in stance in the AD trials compared to the BD condition, finding that was evident in both age groups. Also, a significant age x condition interaction effect was seen in VL, with the older group delaying the activation of this muscle when anticipating slippery surfaces, while young subjects did not. Also, older subjects activated their MH earlier in stance with anticipation compared to young subjects.

Table 1: Mean Onset (standard error)

Onsets in % Stance	CONDITION			
	BD		AD	
	Older	Young	Older	Young
VL	-13.91 (1.02)	-14.27 (1.08)	-10.64 (2.02)	-15.84 (1.47)
MH	-14.26 (5.05)	-24.12 (1.15)	-19.10 (1.56)	-25.38 (.93)
TA	-9.62 (1.29)	-2.39 (3.09)	-9.03 (2.08)	-3.70 (3.14)
MG	20.39 (6.48)	23.18 (4.65)	8.04 (6.50)	3.22 (5.78)

Anticipation resulted in increased stiffness at the ankle and knee in both age groups (Figure 1). Additionally, significant age x condition interaction effects were seen at the knee as younger subjects increased stiffness in the AD trials compared to their BD levels more than older subjects, especially post HC. Interesting age-related differences in knee stiffening strategies exist between the pre- and post- HC phases as well.

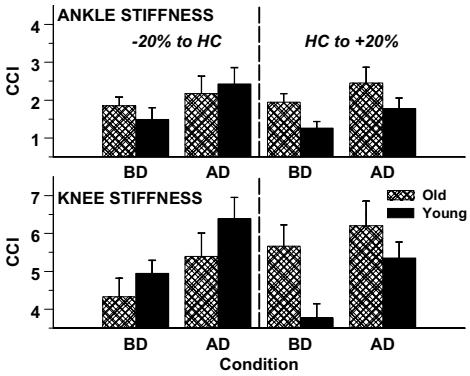

Figure 1: Ankle (top) and knee (bottom) CCI from -20% to HC (left) and from HC to 20% into stance (right) (standard error bars)

DISCUSSION AND CONCLUSIONS

In summary, anticipating slippery surfaces affects lower leg muscle activation onsets and ankle/knee stiffness. While young and older subjects adopted similar strategies at the ankle when anticipating slippery floors, there were age-related differences associated with the upper leg muscles. It is worth noting the most critical recovery responses to slips are generated at the knee and hip, not the ankle [9].

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