FOOTWEAR IS AN IMPORTANT DETERMINANT FOR MEDIAL-LATERAL STABILITY DURING HILL TRANSITIONS IN WALKING HUMANS

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INTRODUCTION

Walking on sloped surfaces increases the risk of falls in the elderly [1], the leading cause of unintentional injury in the United States. However, it is nearly impossible for individuals to avoid surface transitions when walking either inside or outside during daily life. An appropriate biomechanical response to reduce the risk of falling during these transitions is to change your base-of-support by altering medial-lateral step width [2]. Furthermore, the proper control of step width requires cutaneous feedback from the plantar surface of the foot [3]. Since footwear can cause changes in gait patterns as well as affect cutaneous feedback, [3,4,5] many people may be experiencing reduced feedback as a result of thick cushioning in their shoes. Although individuals at risk for falling may require cushioned insoles to reduce loading forces, a prescribed textured foam insole may provide support without reducing cutaneous feedback. We hypothesize that textured foam insoles will decrease step width and muscle activity as compared to regular shoes. Conversely, similar to icing the plantar portion of the foot, thick cushioned insoles will increase step width and muscle activity as compared to regular shoes.

METHODS

Five healthy college-aged participants, 4 men and 1 woman, completed the protocol.

We placed reflective markers over the posterior calcaneus (heel) and the first metatarsal (toe) to be recorded using a six camera photogrametry system. Electromyography surface electrodes were placed over the soleus muscles to record muscle activity.

Participants completed five walking conditions on a 15 degree ramp: Level, Level → Uphill, Uphill → Level, Level → Downhill, and Downhill → Level (Figure 1). The walking trials were repeated for each of the following footwear conditions: personal athletic shoes, personal athletic shoes with foam insoles, personal athletic shoes with textured insoles, barefoot, and iced. For each trial, we measured the medial-lateral distance between the left and right heels as well as muscle activity for the soleus. Lastly, we compared these kinematic and muscle variables across conditions using paired t-tests ($p<0.05$).

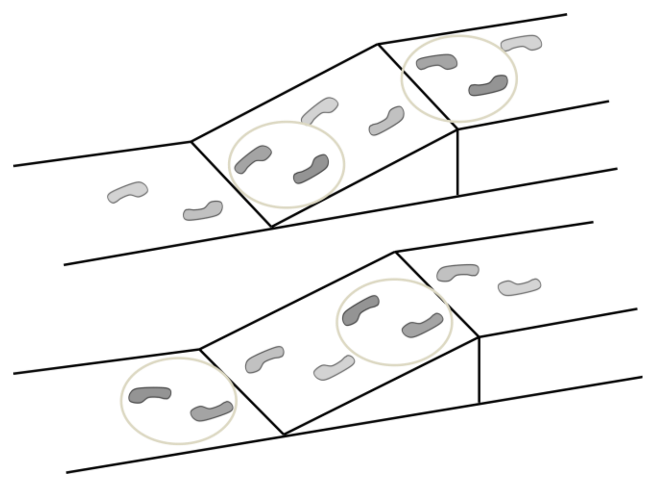

Figure 1: Uphill and downhill step positions. Circled footprints represent the measured step widths at Level → Uphill, Uphill → Level, Level → Downhill, and Downhill → Level (clockwise from top left).

RESULTS AND DISCUSSION

To summarize, medial-lateral step width and soleus activity were greater during the conditions utilizing the foam insoles compared to the conditions with regular and textured insoles.

Specifically, the soleus, which aids in postural stability, was 32% higher using the foam insoles as compared to regular shoes during level walking.

Furthermore, during the foam insole conditions, heel step width was significantly higher in all transition steps and level walking. Potentially, the participants walked with a larger base of support to increase medial-lateral stability due to decreased sensory feedback. Conversely, as seen in Table 1, during the textured insole conditions, heel step width was significantly smaller than foam insoles ($p<0.05$, Downhill → Level $p<0.07$). Possibly, the participants were able to maintain this energetically economic step width due to the increased sensory feedback provided by the textured insole.

During the Uphill → Level and Downhill → Level trials, we assumed that step width would not differ from that of level walking since both feet are on a level surface. However, in the foam insole and ice conditions, the participants' step width increased by 19.5% to 42.5%. Whereas, during the textured insole and barefoot conditions step width only differed by 2.3% to 13% from level walking.

CONCLUSIONS

Our results demonstrated that foam insoles led to a larger step width thereby causing a possible reduction in medial-lateral stability as compared to regular shoes. Textured insoles did not significantly improve medial-lateral stability as compared to regular shoes; however, unlike foam insoles, medial-lateral stability did not decrease with the additional textured insole. Therefore, we surmise that a foam insole with a textured surface could offer additional cushioning to regular shoes without compromising cutaneous feedback.

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Table 1: Mean heel step width and soleus muscle activity for all subjects, normalized to level walking in regular shoes and bare feet. Bold values represent significant ($p<0.05$) differences from Level Regular, and asterisks (*) represent significant ($p<0.05$) differences between footwear conditions.

Mean Normalized Medial-Lateral Step Width at Heel					
Condition:	Regular	Foam	Textured	Barefoot	Ice
Level	100.00	**133.36***	**87.65***	100.00	100.91
Level → Uphill	95.00	**126.27***	104.20*	117.81	112.57
Uphill → Level	**110.35**	**131.23***	98.02*	97.71	119.58
Level → Downhill	**118.98**	**134.16***	118.88*	102.23	98.20
Downhill → Level	**109.79**	**142.59**	**110.10**	113.17	126.36

Mean Normalized Soleus Muscle Activity					
Condition:	Regular	Foam	Textured	Barefoot	Ice
Level	100.00	**131.91***	101.21*	87.01	92.89
Level → Uphill	**180.38**	**204.26**	**221.45**	**179.23**	**174.77**
Uphill → Level	109.35	113.73	104.90	109.61	103.84
Level → Downhill	100.78	107.92	107.23	86.26	94.05
Downhill → Level	**124.68**	**154.87**	**160.05**	149.37	160.85