Comparison of Utilized Coefficient of Friction Requirements in Older Persons with and without a Disability to Younger Persons During Different Walking Tasks

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Introduction: Falls are the leading cause of unintentional injuries resulting in death in persons 65 years of age or older.[1] Among older persons, slips have been identified as one of the primary causes of falls.[2] The presence of gait disorders in persons who are older has been estimated to increase the risk of falling three-fold, while the presence of weakness increases the risk of falling nearly five-fold.[3] During walking, slips result from a loss of traction (i.e., friction) between the foot and the floor. While data exist on the slip resistance necessary for younger persons without a disability to walk on level surfaces[4-7] and ramps,[8] the slip resistance required for persons who are older and/or who have a disability has received only limited examination.[6] Therefore, the purpose of this study was to determine if older persons with medical diagnoses contributing to gait changes have higher utilized coefficient of friction (COF_U) requirements, and therefore greater slip potential, than healthy older or younger adults.

Statement of Clinical Significance: Identification of the slip resistance needs of persons who are older or disabled, across a variety of potentially slip-invoking situations, is critical to reducing the incidence of slips, falls, injuries, and deaths. The reduction of deaths from falls has been identified as a national priority within *Healthy People 2010 Objectives for Improving Health*.

Methodology: Community-dwelling adults capable of independent ambulation, were divided into groups based on medical diagnosis and age: CVA (n = 10; unilateral stroke; mean age 62 yrs); DM (n=10; diabetes mellitus; mean age 70 yrs); ARTH (n=8; lower extremity arthritis; mean age = 69 yrs); SENIOR (n=10; healthy; mean age 73 yrs); and YOUNG (n=10; healthy; mean age 29 yrs). Ground reaction forces (AMTI force plates; 1200 Hz; 4th order, 45 Hz low-pass Butterworth filter) were recorded as subjects walked at a self-selected speed across a 10-m level walkway; ascended and descended a 4-step staircase (depth 28cm; height 20 cm; force plate located 2nd stair from lower landing); and turned. The order of tasks was randomized. Two trials of each task were recorded and averaged. The COF_U throughout stance for the more involved limb (CVA; ARTH) or left limb (DM, SENIOR, YOUNG) was calculated as the ratio of the resultant shear to vertical ground reaction forces using the following formulae: COF_U = Shear/Vertical. To avoid spurious COF_U values, only COF_U data in which the vertical ground reaction force exceeded 50N were analyzed.[5] During weight acceptance, the peak COF_U resulting from a shear force that would contribute to a forward foot slip was identified. Separate 5x4 (group x task) ANOVAs with repeated measures were used to identify differences in peak COF_U, normalized vertical ground reaction force (% BW) and normalized resultant shear ground reaction force (% BW) at the time of peak COF_U. An alpha level of .05 was used to test for significance.

Results: Collapsed across walking tasks, the peak COF_U did not differ significantly between subject groups (Table 1). Collapsed across subject groups, the peak COF_U during turning (μ= .36) and stair decent (μ= .37) were higher than both level walking (μ= .25; p<.001) and stair ascent (μ= .25; p<.001). When collapsed across subject groups, the normalized *vertical* ground reaction force at the moment of peak COF_U was significantly higher during level walking compared to turns (69 vs. 52 % BW; p=.025), and during both level walking and turns compared to stair ascent (29% BW, p<.01) and stair descent (23% BW, p<.001). When collapsed across subject groups, the normalized *shear* ground reaction force at the moment of peak COF_U was significantly higher during level walking (15% BW) and turns (15% BW) compared to stair ascent (5% BW, p<.001), and stair descent (7% BW, p<.001). The normalized *shear* ground reaction force at the moment of peak COF_U during stair descent was significantly higher than during stair ascent (7 vs. 5% BW, p<.01).

Table 1. Mean peak COF_U during weight acceptance.

	Level	Turn	Ascend	Descend
SENIOR	.26 (.15)	.38 (.11)	.22 (.09)	.39 (.08)
CVA	.31 (.13)	.31 (.11)	.22 (.10)	.36 (.07)
DM	.20 (.03)	.32 (.14)	.31 (.11)	.41 (.11)
ARTH	.24 (.08)	.38 (.21)	.19 (.08)	.41 (.10)
YOUNG	.24 (.03)	.39 (.09)	.29 (.12)	.30 (.12)
Combined	.25 (.10)	.36 (.14)	.25 (.11)	.37 (.10)

Discussion: The lack of significant differences in COF_U between subject groups suggests that the individuals with the selected medical conditions tested in this study were not at any greater risk of slipping than the healthy older or younger adults during various walking tasks at self-selected speeds. For all subject groups, the higher COF_U values during stair descent and turning suggest an increased risk of slipping during these two tasks when compared to level walking and stair ascent. Compared to other tasks, COF_U values during level walking were lower as a result of higher vertical ground reaction forces. During turns, higher COF_U values were the result of higher shear forces. During stair descent, high COF_U values resulted primarily from lower vertical ground reaction forces.

References:

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