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Association between Anthropometric Factors and Falls in Community-Dwelling Older Adults During a Simulated Slip While Walking

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To the Editor:

Slip-related falls are a major public health problem facing older adults worldwide. Approximately 25% to 39% of community-dwelling people aged 65 and older experience at least one fall per year, and approximately half of them may have two or more falls (1–3). The primary purpose of this study was to determine whether and to what extent anthropometric factors such as body mass, height, and foot size could predispose older adults to falls after a sudden and unrehearsed slip induced in walking.

METHODS

Community-dwelling older adults (N=187, 129 female; aged 72 ± 5; height 166 ± 9 cm; weight 76 ± 14 kg) participated in the gait-slip experiment. All subjects experienced an unannounced slip while walking on a suddenly unlocked low-friction section of a 7-m walkway under the protection of safety harness. Fall and recovery were the two outcome of the slip trial (4). Characteristics of the outcome groups were compared using independent t-tests for continuous variables and chi-square tests for categorical variables. For body height and foot size, a distribution analysis was performed to determine the cutoff point for classifying older adults into

high risk and low risk of falls groups. Univariate and multivariate logistic regression analyses were used to examine the risk factors for falls. Variables that demonstrated $p < .15$ in the univariate analysis were included in the subsequent multivariate regression model. Details of the experimental design, data collection, and protocol can be found elsewhere (4, 5).

RESULTS

Of 98 participants (52.4%) who fell, 89 recovered from the slip. Subjects in the fall group were more likely to be female (79% vs 58%, $P < .006$), obese (39% vs 20%, $P < .008$), and on average, shorter (163.9 vs 168.8 cm, $p < .001$) and to have smaller feet (27.75 vs 28.85 cm, $P < .0001$). Body height, foot size, weight, and sex were all significant predictors of falls. Women were approximately 2.6 times as likely to fall as men, and obese subjects were approximately 2.5 times as likely as those who were not obese. In the distribution analysis for height and foot size, subjects who were 165 cm tall or shorter and those with a foot size of 28.5 cm or less were at significantly greater risk of falls. Overall, the fall risk was approximately 2.9 times as great in subjects who were 165 cm tall or shorter and 2.8 times as great in subjects with a foot size of 28.5 cm or less (Table 1) than in their counterparts. In the multivariate analysis, obesity (odds ratio (OR) = 2.38, 95% confidence interval (CI) = 1.17–4.84, $p = .02$), female sex (OR = 3.32, 95% CI 1.37–8.01, $p = .008$), and being shorter (OR = 11.1, 95% CI = 2.04–60.7, $p = .005$) remained significant risk factors for falls. There was also a significant interaction between sex and height ($p = .02$).

DISCUSSION

Older adults with a body mass index (BMI) of 30.0 kg/m^2 or greater were 2.5 times as likely to fall as those with a BMI less than 30.0 kg/m^2 ($p < 0.01$). Body mass itself did not increase a person's risk of falls, but shorter stature did. This contradicts the static stability concept in which

shorter stature, which is associated with a lower center of mass, will be more stable than taller stature. It was also found that body height and foot size were correlated (coefficient of determination = 0.49, $p < .001$). Individuals who fell had smaller feet than those who recovered; model simulation work has demonstrated that foot size is an important factor in the control of dynamic stability (6), and the finding of this study supports the theoretical prediction that a longer foot with a larger margin of stability could lower the risk of falling.

The results revealed that the older adults who are female, shorter (≤ 165 cm), obese (BMI > 30.0 kg/m^2), with shorter foot size (≤27.75cm) were at significantly greater risk of falling. Although women were more prone to falling, there was also significant interaction between sex and height. Older men who were taller than 165 cm were less likely to fall than older women of the same height. Although it is unclear whether height or foot size is the dominant factor, taller men are likely to have less risk of falling because of their longer foot size in comparison than in taller women. The fact that the relationship between height and foot size is more sensitive and stronger in men than in women could explain this. Such findings could provide guidance in developing intervention strategies to reduce falls in older adults.

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Table 1 Univariate Logistic Regression Analysis of Falls

Predictor	Odds Ratio (95% Confidence Interval	P-Value
Height		
Centimeters	0.932 (0.898–0.967)	<.001
≤ 165 vs >165 cm	2.937 (1.619–5.325)	<.001
Weight, kg	0.993 (0.973–1.014)	.51
Age	0.999 (0.944–1.056)	.97
Foot size		
Centimeters	0.764 (0.657–0.888)	<.001
≤ 28.5 vs > 28.5 cm	2.768 (1.526–5.021)	.001
Body mass index (obese vs not obese)	2.498 (1.294–4.823)	.006
Sex	2.609 (1.375–4.951)	.003