Footwear Style and Risk of Falls in Older Adults

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OBJECTIVES: To determine how the risk of a fall in an older adult varies in relation to style of footwear worn.

DESIGN: Nested case-control study.

SETTING: Group Health Cooperative, a large health maintenance organization in Washington state.

PARTICIPANTS: A total of 1,371 adults aged 65 and older were monitored for falls over a 2-year period; 327 qualifying fall cases were compared with 327 controls matched on age and sex.

MEASUREMENTS: Standardized in-person examinations before fall occurrence, interviews about fall risk factors after the fall occurred, and direct examination of footwear were conducted. Questions for controls referred to the last time they engaged in an activity broadly similar to what the case was doing at the time of the fall.

RESULTS: Athletic and canvas shoes (sneakers) were the styles of footwear associated with lowest risk of a fall. Going barefoot or in stocking feet was associated with sharply increased risk, even after controlling for measures of health status (adjusted odds ratio = 11.2, 95% confidence interval (CI) = 2.4–51.8). Relative to athletic/canvas shoes, other footwear was associated with a 1.3-fold increase in the risk of a fall (95% CI = 0.9–1.9), varying somewhat by style.

CONCLUSION: Contrary to findings from gait-laboratory studies, athletic shoes were associated with relatively low risk of a fall in older adults during everyday activities. Fall risk was markedly increased when participants were not wearing shoes. **J Am Geriatr Soc 52:1495–1501, 2004.**

Key words: falls; shoes; elderly

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Falls are the most frequent cause of fatal injury in older Americans.[1] Nonfatal falls are also common, occurring in nearly one-third of community-dwelling older adults each year.[2–5] Falls can lead to hip or other fracture, head trauma, or soft-tissue injury[1,6–8] and are a common reason for hospitalization in older adults.[9] Fear of falling again can itself curtail mobility and quality of life.[10–12] Thus, prevention of falls is an important clinical and public health problem for older adults.

A variety of intrinsic and extrinsic risk factors for falls have been identified.[2,4,5,11,13–18] Footwear is a potentially modifiable factor that has long been thought to play a contributing role in some falls, by any of several mechanisms.[19] A shoe's sole material and tread design can affect the coefficient of friction on the walking surface, which may influence the risk of slipping.[20–23] Heel height and width may affect a shoe's tendency to tip sideways on an uneven surface, as well as gait and posture.[24–29] Sole thickness and shoe collar height may affect proprioception.[30–32]

Two kinds of studies account for much of the research on footwear and falls in older adults. First, laboratory-based studies have examined gait, balance, and tactile perception in relation to features of shoe design, using volunteers under controlled conditions.[24,28,31–34] For example, relatively thick, soft midsoles have been found to interfere with position sense and contribute to instability, as assessed by falls off a balance beam, raising questions about the safety of athletic shoes.[32,35,36] One study found that volunteers performed better on a balance beam in tennis shoes than in cowboy boots.[37] High-heeled shoes have been found to lead to lateral instability and to reduce stride length in a gait laboratory.[25] Nonetheless, the extent to which the results of laboratory studies on healthy volunteers can be validly extrapolated to typical older adults and real-world walking environments remains unclear.

Second, case reports and case series have described the footwear worn at the time of a fall and the faller's belief about whether shoes played a causal role,[7,38,39] but case series may simply reveal which shoe styles older adults most commonly wear. To determine whether the distribution of shoe styles worn by fallers is atypical, information is needed about shoe styles worn by controls who have not fallen.

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The present study was undertaken to investigate the degree to which the style and biomechanical characteristics of footwear were associated with risk of falling in a cohort of community-dwelling older adults. This article focuses on fall risk in relation to shoe style worn.

METHODS

The study was conducted in a predefined cohort of older adult enrollees in Group Health Cooperative, a large consumer-owned health maintenance organization in Washington state. A nested case-control study design was used.

Study Subjects

Study subjects were recruited from among 2,581 adults who were already enrolled in the Adult Changes in Thought (ACT) study, an ongoing prospective study of incidence and risk factors for Alzheimer's disease.[40] Participants in the ACT study had originally been identified by random sampling of Group Health enrollees aged 65 and older. To qualify for the ACT study cohort, subjects had to score 86 or greater on the Cognitive Abilities Screening Instrument (CASI) or be found not to meet clinical criteria for dementia after further diagnostic evaluation despite a low CASI score, as described in detail elsewhere.[40] Some 1,371 ACT study participants who were ambulatory, noninstitutionalized, and willing to take part in the present study became the fall surveillance cohort. Fall occurrence among them was monitored prospectively from July 1998 through June 2000. All cases and controls were drawn from this cohort.

A qualifying fall was defined as an unintentional fall to the ground, not preceded by loss of consciousness and not resulting from an external force (such as being pushed or hit), in a cohort member who was ambulatory at the time of the fall. Falls in persons who depended on a walker at all times were excluded, as were falls involving equipment that supports body weight (such as sports equipment or ladders). Falls qualified for study only if they occurred within King County, so that a visit to the fall site by the study team was practical.

Fallers were asked to call a telephone hotline at the study center as soon as practicable after falling. All cohort members were also supplied with study calendars with attached postage-paid postcards and asked to return one postcard at the end of every month, indicating on it whether they had fallen during the month. Each month, those from whom no postcard was received were contacted by telephone to determine fall status. Cohort members who died, chose to stop participating, or were lost to follow-up were considered no longer under surveillance after their last postcard or follow-up telephone contact.

Once a new fall case was identified, a matched control was selected at random from among all cohort members still under surveillance at the time of the fall who were similar to the faller with regard to age (±3 years) and sex. To limit respondent burden, a person was exempt from further study after he or she had participated once as a case or a control.

Data Collection

After a fall case had been found eligible in a screening telephone interview, a two-person field team visited the faller by appointment at the location of the fall, if feasible, or at the faller's home. Some 93.4% of eligible cases agreed to such a visit, which took place a median of 22 days after the fall. The case was asked to have available the shoes worn at the time of the fall. During the visit, one field worker interviewed the faller about circumstances of the fall and about other risk factors. Meanwhile, the second field worker took biomechanical measurements of the case's right foot, the right shoe worn at the time of the fall, and the environment where the fall had occurred.

The activity in which the case was engaged at the time of the fall was classified into one of five categories: walking indoors, walking outdoors, climbing stairs, moderate activity (such as vacuuming floors), or vigorous activity (such as playing tennis). When a potential control was then contacted by telephone, the control was asked to recall the most recent occasion on which he or she had been engaged in an activity in the category that included what the matched case was doing at the time of the fall. That occasion for the control then determined a reference date, time, and location. The footwear worn by the control on that occasion was then characterized in the same manner as for the case. Ultimately, 97.3% of selected controls agreed to be visited by the field team, and they were interviewed a median of 8 days after the reference date.

Except for questions about the fall itself, the same standardized questions were asked of cases and controls. Topics included sociodemographics, self-reported health status, mobility, health behaviors, footwear wearing habits, and social/recreational activities in the previous month. Most questions in the interview were drawn from ACT study instruments or from previous surveys involving older adults. Participants had also previously undergone a standardized in-person interview and examination every 2 years as part of the ACT study. Data on grip strength, difficulty rising from bed or chair, and presence or absence of any gait abnormality were available from the most recent such visit for use in the present study.

Data Analysis

The incidence rate of falls was estimated as the number of fall cases divided by total person-time at risk in cohort members. For the main analyses, odds ratio (OR) estimates and 95% confidence intervals (CIs) were obtained from conditional logistic regression. This analytic method yielded an estimate of the adjusted relative odds of a fall among wearers of each shoe type, relative to wearers of a reference shoe type, after statistically adjusting for potential confounding factors such as measures of health status. For convenience of presentation, most tables show the prevalence of exposures in all cases and controls, ignoring matching.

Because of the wide variety of footwear worn by cases and controls, three separate schemes were used to categorize footwear styles, involving 12, five, or three footwear categories. The 12-category scheme required fewest assumptions about which factors should be used to combine styles into broader categories, but because of the small

number of cases and controls in any given category, CIs around estimates of effect were wide. For the five- and three-category schemes, styles were combined based on structural shoe design features, the daily activities for which shoes would typically be used, and observed frequency of use.

All analyses were performed using Stata 7.0 (Stata Corporation, College Station, TX). Institutional review boards at the University of Washington and Group Health Cooperative reviewed and approved the study.

RESULTS

A total of 327 qualifying falls occurred in 1,900.6 person-years of follow-up, for an overall rate of 17.2 per 100 person-years at risk. Another 345 falls reported by participants were excluded: 88 occurred outside the study area, 59 occurred in subjects who were not ambulatory at the time, 52 were not falls to the ground, 46 occurred after a loss of consciousness, 41 were caused by an external force, 31 occurred on supportive equipment, 15 occurred in subjects who used mechanical aids, and 25 were excluded for other reasons.

Most falls occurred in or around the home, 61% of them outdoors. About 62% took place while walking on a level surface, 13% on a slope, and 23% where there was a change in surface level, such as stairs, steps, or a curb. About 30% occurred between 6:00 p.m. and noon, 48% between noon and 6:00 p.m., 20% between 6:00 p.m. and midnight, and fewer than 3% between midnight and 6:00

Table 1. Demographic Characteristics, Health Status, and Ambulation Status of Cases and Controls

Characteristic	Cases n (%)	Controls n (%)	Odds Ratio (95% Confidence Interval)	*P*-value
Age			(Matching factor)	
65–69	20 (6)	18 (6)		
70–74	102 (31)	99 (30)		
75–79	96 (29)	100 (31)		
80–84	60 (18)	72 (22)		
≥85	49 (15)	38 (12)		
Sex			(Matching factor)	
Female	221 (68)	221 (68)		
Male	106 (32)	106 (32)		
Self-reported health status				.66*
Excellent	43 (13)	37 (11)	1.0 (Reference)	
Very good	128 (39)	128 (39)	0.9 (0.5–1.4)	
Good	112 (34)	117 (36)	0.8 (0.5–1.4)	
Fair	34 (10)	37 (11)	0.8 (0.4–1.5)	
Poor	10 (3)	8 (2)	1.1 (0.4–2.9)	
Physically active				.75*
Not at all	35 (11)	30 (9)	1.0 (Reference)	
A little	58 (18)	49 (15)	1.0 (0.6–1.9)	
Fairly	97 (30)	116 (35)	0.7 (0.4–1.3)	
Quite	86 (26)	81 (25)	0.9 (0.5–1.6)	
Very	41 (13)	45 (14)	0.8 (0.4–1.5)	
Extremely	10 (3)	6 (2)	1.3 (0.4–4.2)	
Grip strength in dominant hand				.002*
<19.5	99 (31)	73 (22)	1.0 (Reference)	
19.5–24.4	72 (22)	83 (26)	0.6 (0.4–1.0)	
24.5–31	83 (26)	79 (24)	0.6 (0.4–1.1)	
>31	69 (21)	90 (28)	0.3 (0.2–0.6)	
Difficulty getting up from bed or chair				.013
No	238 (73)	264 (81)	1.0 (Reference)	
Yes	89 (27)	62 (19)	1.6 (1.1–2.3)	
Difficulty walking at home				.054
No	286 (88)	301 (92)	1.0 (Reference)	
Yes	40 (12)	25 (8)	1.7 (1.0–2.8)	
Any gait abnormality				.015
No	249 (83)	280 (90)	1.0 (Reference)	
Yes	52 (17)	32 (10)	1.8 (1.1–3.0)	
Use any walking aids				.021
No	257 (79)	279 (85)	1.0 (Reference)	
Yes	70 (21)	48 (15)	1.6 (1.1–2.5)	

* From test for trend.

Table 2. Fall Risk in Relation to Footwear Worn, Using Three Schemes for Categorizing Shoe Styles

Footwear type	Cases n (%)	Controls n (%)	Odds Ratio (95% Confidence Interval)	*P*-value
Twelve categories				.001
Athletic	97 (30)	125 (38)	1.0 (Reference)	
Canvas shoes	13 (4)	19 (6)	0.9 (0.4–1.9)	
Lace-up oxfords	58 (18)	59 (18)	1.2 (0.8–1.9)	
Loafers	29 (9)	30 (9)	1.4 (0.7–2.5)	
Flats	18 (6)	15 (5)	2.0 (0.9–4.5)	
Boots	12 (4)	8 (2)	1.8 (0.7–4.6)	
High heels	12 (4)	8 (2)	2.4 (0.8–6.8)	
Sandals	14 (4)	15 (5)	1.4 (0.6–3.2)	
Slippers	29 (9)	29 (9)	1.3 (0.7–2.4)	
Other shoe style	18 (6)	13 (4)	2.2 (0.9–5.5)	
Stocking feet	12 (4)	3 (1)	5.5 (1.5–20.7)	
Barefoot	12 (4)	1 (<1)	inf. —	
Five categories				<.001
Athletic/canvas	110 (34)	144 (44)	1.0 (Reference)	
Lace-up oxfords	58 (18)	59 (18)	1.2 (0.8–1.9)	
Loafers/flats	47 (15)	45 (14)	1.5 (0.9–2.5)	
Other shoe style	85 (26)	73 (22)	1.7 (1.1–2.6)	
Shoeless	24 (7)	4 (1)	11.1 (3.2–38.3)	
Three categories				<.001
Athletic/canvas	110 (34)	144 (44)	1.0 (Reference)	
Other shoe style	190 (59)	177 (54)	1.5 (1.0–2.0)	
Shoeless	24 (7)	4 (1)	10.2 (3.0–35.0)	

a.m. The most common activity at the time of the fall was walking outdoors (43%), followed by walking indoors (31%), and climbing or descending stairs (15%). Only about 10% of falls occurred during moderate physical activity and fewer than 2% during vigorous exercise. About 36% of falls involved tripping on something, 23% involved an elevation change, 13% involved slipping, and the rest involved various other mechanisms. Most (65%) fall-related injuries were contusions or lacerations, but there were 15 fractures (4 hip, 5 hand/wrist, 6 other) and 15 head injuries. Overall, 25% of falls resulted in a medical care visit.

As shown in Table 1, matching produced case and control groups of similar age and sex. Cases and controls also proved to be similar on self-reported health status and on physical activity during the 4 weeks before the reference date, but cases appeared to be less healthy than controls before the reference date on several interview and examination measures. Cases had weaker grip strength in the dominant hand, were more likely to report difficulty with rising from a bed or chair or with walking around the home, were more likely to have been observed to have some form of gait abnormality at their most recent ACT study visit, and were more likely to use a mechanical aid (e.g., cane or walker) at least part of the time.

The most commonly worn style was athletic shoes, which was used as the reference exposure group under the 12-category scheme (Table 2). Relative to those wearing athletic shoes, risk of a fall was higher for wearers of nearly all other shoe styles under the 12-category scheme, although CIs around the ORs were quite wide because of the small number of subjects in each footwear style category. Nonetheless, fall risk was markedly elevated for persons who were barefoot or in stocking feet at the reference time.

Like athletic shoes, canvas shoes (sneakers) are used for casual activities and have relatively wide rubber or crepe soles and fabric upper material and low heel height. On this basis, and because they appeared empirically to be similar to athletic shoes in their association with fall risk under the 12-category scheme, they were combined with athletic shoes to form the reference category in the five- and three-category schemes. Bare feet and stocking feet were combined into a single shoeless category. For the five-category scheme, lace-up oxfords and loafers or flats were sufficiently common to warrant keeping them as separate categories, whereas both were combined with all other shoe styles in the three-category scheme. As shown in Table 2, athletic/canvas shoes were the lowest-risk category under all three schemes, whereas shoeless was the highest-risk category.

Health status was regarded as an important potential confounding factor. Table 1 shows associations between several measures of health status and increased risk of a fall. Also, the style of shoe most commonly worn could plausibly differ in relation to health status. Table 3 shows the observed associations between shoe style use and several measures of health status. Cases and controls are combined in Table 3, but results were similar when stratified by case-control status. Using the three-category scheme, the distribution of footwear styles differed most markedly in relation to measures of health directly related to walking: namely, presence of any gait abnormality and use of a mechanical aid when walking. Both factors were associated with higher likelihood of being shoeless and lower likelihood of wearing athletic/canvas shoes.

Table 3. Type of Footwear Worn at Reference Time in Relation to Measures of Health Status

Characteristic	n	Footwear Worn at Reference Time: Athletic/Canvas (%)	Other Shoe (%)	Shoeless (%)	*P*-value
Self-reported health status					.77
Good or better	561	39	57	4	
Fair or poor	88	38	57	6	
Sedentary					.81
No	584	40	56	4	
Yes	65	35	60	5	
Grip strength in dominant hand					.93
>31	155	36	61	3	
24.5–31	162	41	55	4	
19.5–24.4	154	42	54	5	
<19.5	172	39	56	5	
Difficulty walking at home					.29
No	582	40	56	4	
Yes	65	31	63	6	
Difficulty rising from bed or chair					.086
No	498	41	55	4	
Yes	65	32	62	6	
Use walking aid					.001
No	531	41	56	3	
Yes	118	31	59	10	
Abnormal gait:					.014
No	524	42	55	3	
Yes	84	31	56	8	

In Table 4, results from four conditional logistic regression models are shown, using the three-category scheme for footwear styles. Persons who were shoeless at reference time were seen to have an 8 to 11 times greater risk of a fall than wearers of athletic/canvas shoes, even after controlling for grip strength, difficulty rising from a bed or chair, or presence of any gait abnormality. Wearing a shoe style other than athletic/canvas shoes was associated with more modestly elevated fall risk, ranging from 30% to 50% excess risk across models. These ORs were similar when controlled for other measures of health status (not shown).

Table 5 shows how the estimated relative risk of a fall varied in relation to footwear worn, divided into the five broad categories of activities at reference time. Because of small numbers, no attempt was made to control statistically for other potential confounders beyond the matching factors. Some combinations of activity type and footwear type were too rare to allow relative risks to be estimated. Nonetheless, when risk comparisons by style were possible across the four most common activity types, athletic/canvas shoes were consistently associated with lowest risk of a fall, whereas going shoeless was associated with highest risk.

DISCUSSION

It was found that athletic and canvas shoes—the styles of footwear most commonly worn by this sample of older adults—were associated with lowest risk of falling, whereas going shoeless was associated with markedly higher risk of a fall. These associations held up across three footwear

Table 4. Multivariate Analysis of Fall Risk in Relation to Shoe Style (Three Categories)

Model	Adjusted for Matching Factors* Plus	Odds Ratio† (95% Confidence Interval): Nonathletic Shoe		Shoeless	
1	Nothing else	1.5	(1.0–2.0)	10.2	(3.0–35.0)
2	Grip strength	1.4	(1.0–2.0)	8.9	(2.6–30.7)
3	+ Difficulty rising from bed or chair	1.4	(1.0–2.0)	8.8	(2.5–30.5)
4	+ Any gait abnormality	1.3	(0.9–1.9)	11.2	(2.4–51.8)

* Age, gender, and category of activity at reference time.
† Relative to athletic = canvas shoes.

Table 5. Fall Risk in Relation to Footwear Worn, by Activity at Reference Time

Activity	n	Odds Ratio* (95% Confidence Interval)			
		Nonathletic Shoe		Shoeless	
Walking indoors	102	1.3	(0.8–2.0)	12.7	(2.8–56.1)
Walking outdoors	139	1.2	(0.6–2.5)	—	—
Climbing or descending stairs	50	2.6	(0.9–7.3)	5.2	(0.4–70.9)
Moderate activity	31	3.0	(0.8–11.1)	—	—
Vigorous activity	5	0.5	(0.5–5.5)	—	—

* Relative to athletic/canvas shoes.

categorization schemes; across several multivariate analyses that controlled for age, sex, and various indicators of health status; and across activity groupings that collectively accounted for a large majority of the activities reported by cases and controls.

Several study limitations should be borne in mind when interpreting these results. The study involved a cohort of volunteers who may have been healthier and more active than nonvolunteers. This may help explain why the observed incidence of falls in this cohort was lower than that reported elsewhere,[11,41] although the relatively restrictive definition of falls eligible for study also probably contributed. The study relied on self-reported occurrence of falls and on accurate recall of shoe styles worn by cases and controls, which was potentially subject to error. The study's power to detect a statistically significant difference in risk associated with a particular type of footwear depended in part on how commonly study subjects reported wearing that type. Effects of shoe styles that were worn relatively rarely, such as high heels, may have escaped detection. Likewise, characteristics of the faller may have modified any effects of footwear styles on fall risk, and particularly high- or low-risk combinations of extrinsic and intrinsic factors may have occurred too rarely for this effect to be discovered. As in nearly all nonrandomized studies, unknown or unmeasured confounding factors may have distorted the associations observed.

Studies on volunteers in gait laboratories have raised concerns that athletic shoes may be associated with increased risk of a fall in older adults. Athletic shoes have relatively thick, soft midsoles that may interfere with position sense.[31,32,35,36] In contrast, it was observed that athletic shoes were associated with a lower risk of a fall compared with various other shoe types. The discrepancy may mean that performance in a controlled laboratory setting may not translate fully to performance in the activities and environments of everyday life of older adults. Also, athletic shoes have other design features besides thick, well-cushioned midsoles that may decrease fall risk, such as a relatively high sole coefficient of friction and a low, wide heel.

It was found that going barefoot or wearing only stockings was associated with markedly increased fall risk. Going shoeless might be expected to be more common in relatively sedentary, housebound adults, who may be at increased risk for falling. In fact, going shoeless was more common in persons with a gait abnormality or who used a mechanical aid for walking at least part of the time. Nonetheless, the strong association with risk of a fall persisted after controlling for these characteristics. Although being barefoot has been associated with good balance performance in the laboratory,[27] without shoes the foot is more vulnerable to painful trauma if an unexpected obstacle is encountered. Moreover, stocking feet may provide a poor coefficient of friction and thus be more prone to slipping.

In summary, this study found that risk of a fall in older adults varied significantly in relation to footwear style. This information may provide useful guidance for older adults in deciding what kinds of shoes to buy and wear. The findings also suggest that promotion of footwear styles associated with low fall risk may be a useful component of intervention programs designed to help prevent falls.

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