Older Women With Diabetes Have a Higher Risk of Falls

A prospective study

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OBJECTIVE — To determine whether older women with diabetes have an increased risk of falls and whether known risk factors for falls account for any increased risk.

RESEARCH DESIGN AND METHODS — This prospective cohort study included 9,249 women ≥67 years of age enrolled in the Study of Osteoporotic Fractures. Diabetes was determined by questionnaire at baseline. Physical performance was measured at the second examination. Subsequently, falls were ascertained every 4 months by postcard.

RESULTS — A total of 629 (6.8%) women had diabetes, including 99 who used insulin. During an average of 7.2 years, 1,640 women (18%) fell more than once a year. Diabetes, stratified by insulin use, was associated with an increased risk of falling more than once a year (age-adjusted odds ratio [OR] 1.68 [95% CI 1.37–2.07] for non–insulin-treated diabetes; age-adjusted OR 2.78 [1.82–4.24] for insulin-treated diabetes). In the first 2 years of follow-up, women with diabetes were not more likely to fall than women without diabetes (44 vs. 42%; $P =$ 0.26), but they had more falls (3.1 vs. 2.4; $P < 0.01$). Women with diabetes were more likely to have other risk factors for falls, which appeared to account for the increased risk of falls associated with non–insulin-treated diabetes (adjusted OR 1.18 [0.87–1.60]) but not insulin-treated diabetes (adjusted OR 2.76 [1.52–5.01]).

CONCLUSIONS — Older women with diabetes have an increased risk of falling, partly because of the increased rates of known fall risk factors, and may benefit from interventions to prevent falls. Further research is needed to determine whether diabetes treatment reduces fall risk.

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Falls are the leading cause of nonfatal injury among the elderly (1). Fractures are one of the most serious fall-related injuries, and diabetes appears to increase the risk for fracture (2–4). Falls might account for some of the increased fracture risk associated with diabetes, but little is known about falls among older women with diabetes (5–8). We used prospective data on falls from the Study of Osteoporotic Fractures to determine whether older women with diabetes have a higher risk of falls and whether known risk factors for falls account for any increased risk (9).

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Abbreviations: OR, odds ratio.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

RESEARCH DESIGN AND METHODS — The Study of Osteoporotic Fractures is a prospective cohort study of osteoporosis and fractures in older women. The study has been described in detail previously (10). Briefly, 9,704 white women ≥65 years of age were enrolled between 1986 and 1988 from population-based listings in four areas: Portland, OR; Minneapolis, MN; Baltimore, MD; and the Monongahela Valley near Pittsburgh, PA. The coordinating center was located at the University of California San Francisco.

Participants attended a baseline clinic visit and returned every 2 years. Peripheral neuropathy, a covariate of particular interest in this analysis, was measured at the second clinic visit. Therefore, this study considers falls reported after the second visit. Of the 9,339 women participating in the second visit, 23 were excluded because of lack of information on history of diabetes and 67 were excluded because of lack of fall data, leaving a total of 9,249 women. In the multivariable models, 3,819 women were excluded because of missing covariates. All participants provided informed consent, and the protocol was approved by the institutional review boards of the participating institutions.

History of diabetes

At baseline (1986–1988), participants were asked if a doctor had ever told them that they had diabetes or "sugar" diabetes. Women who answered "yes" were also asked for their age at diagnosis and current insulin use. Information on oral hypoglycemic medications was not obtained. At the fourth visit (1992–1994), participants were asked the same questions regarding diabetes.

Falls

After the second clinic visit, participants' falls were monitored every 4 months by postcard. A fall was described to participants as "landing on the floor or ground, or falling and hitting an object like a table or stair." If participants did not return the card, they were contacted by telephone. Participants returned an average of 21.6 (± 5.7) cards for a mean follow-up time of 7.2 (± 1.9) years.

Baseline clinic visit

A baseline questionnaire assessed targeted medical history, walking for exercise, and use of seizure medications. Measures of vision included corrected visual acuity (letter charts of Bailey and Lovie [11]), near depth perception (random dot method [12] in seconds of arc), far depth perception (Howard-Dohlman device [13]), and contrast sensitivity (14) (Vistech contrast sensitivity test system, Model 6500). To assess postural dizziness, the participant was asked if she felt dizzy, lightheaded, or "woozy" 1 min after standing up from lying down on an examining table.

Second clinic visit

The questionnaire at the second visit (1989–1990) assessed targeted medical history, fainting in the past year, back pain, and functional status. Cognitive function was assessed with the Trails B and Digit Symbol tests (15). Depression was measured with the 15-item Geriatric Depression Scale (16). The standard cutoff point of six or more symptoms was used to define depression. Use of medications for sleeplessness, anxiety, or nervousness or to relax muscles was queried.

Height was measured by a Harpenden stadiometer (Holtain, Dyved, U.K.); weight was measured with a standard balance beam scale. Grip strength was assessed using a grip dynamometer (Preston Grip dynamometer; Takei Kiki Kogyo, Tokyo). Quadriceps strength was measured as the average force generated during a 4-s interval using a Bodymasters MD110 leg extension chair (Lafayette Instruments). Walking speed was the average time to complete two trials on a 6-m course. The chair stand test measured how long it took a participant to stand up from a chair five times without using her arms. The tandem stand (eyes open) was scored as poor if the participant could not stand for at least 10 s with her feet in a tandem position. Tandem stand performance was entered as a categorical variable with three levels: good, poor, and refused or unable to perform. For the tandem walk, participants walked heel-to-toe along a 2-m line. The number of errors (e.g., stepping off the line) was added to the time to complete the walk in seconds to obtain a tandem walk score. Tandem walk score was entered as a categorical variable with five levels, including a separate category for "refused or unable to perform."

Peripheral neuropathy

Lower-extremity vibration sensitivity was measured using the Vibratron II (Sensortek, Clifton, NJ) with a two-alternative forced choice procedure (17). The vibration intensity was decreased until the participant had made five errors. Using the five lowest correct scores and the five errors, the highest and lowest values of these 10 scores were excluded. Vibration threshold was calculated by averaging the remaining eight scores. A lower vibration threshold indicates better sensitivity. Pressure sensitivity was measured using the Von-Frey type esthesiometer probes on a warmed great toe. Participants who could not detect filaments smaller than 5.07 (log force applied) were classified as having loss of pressure sensitivity (18).

Statistical analysis

Because we found different fracture risk profiles for individuals using insulin in a previous study (2), characteristics of the cohort are presented separately for women who reported no history of diabetes, diabetic women who were not using insulin, and diabetic women using insulin. The χ^2 and *t* tests were calculated to assess the statistical significance of differences between groups.

The rate of falls was calculated with the number of falls reported after the second clinic visit as the numerator and the time accounted for by completed postcards as the denominator. Logistic regression models were used to estimate the risk of falling. The dichotomous outcome for these models was falling more than once per year versus falling less often, based on the rate of falls. SAS software was used for analyses (19).

A multivariable logistic regression model for falling more than once a year was constructed, using backward regression. Variables were selected for initial entry into the multivariable model if they were associated with falling in age-adjusted models and associated with diabetes ($P < 0.05$). Where possible, measurements taken at the second clinic visit were used. The variables considered were age, vibration threshold, pressure sensitivity, dizziness upon standing (baseline), fainting in previous year, current use of medications for sleeplessness or anxiety, stroke, coronary heart disease, arthritis, difficulty with instrumental activities of daily living, grip strength, quadriceps strength, walking speed, tandem stand eyes open, tandem walk, chair stands, visual acuity (baseline), contrast sensitivity (baseline), near depth perception (baseline), distant depth perception (baseline), positive Geriatric Depression Scale score, and cognitive function (Digit Symbol and Trails B tests). Variables were retained that were statistically significant ($P < 0.05$). The two variables for history of diabetes with and without insulin treatment were then added to determine the multivariable-adjusted association between diabetes and falling. The contribution of each variable to increased risk among women with diabetes was assessed by comparing the coefficients of the diabetes variables in the age-adjusted logistic regression model with those in a model controlling for age and the risk factor of interest (20).

RESULTS — In this cohort of older women, 6.8% reported a history of diabetes and, of those, 15.7% were using insulin. Many of the previously identified risk factors for falls that we considered were more prevalent among women with diabetes (Table 1). Risk factors for falls tended to be most common among individuals using insulin. Variables that were not associated with diabetes in this cohort were history of chronic obstructive pulmonary disease (COPD) or Parkinson's, back pain, and use of seizure medication. Variables that were not associated with risk of falling more than once a year in this cohort were BMI and walking for exercise.

Women with diabetes had higher age-specific rates of falls than women without diabetes (Table 2). A higher proportion of women with diabetes fell more than once a year and more than twice a year compared with women without diabetes. To facilitate comparison with previous studies that have followed participants for 1 or 2 years, we calculated the proportion of

Table 1—*Characteristics of older women in the Study of Osteoporotic Fractures by diabetes and insulin use*

	No diabetes	Non–insulin-treated diabetes	Insulin-treated diabetes
n	8,620	530	99
Age (years)	73.6 ± 5.3	73.9 ± 5.0	73.5 ± 5.0
Time since diagnosis of diabetes (years)	—	11.3 ± 9.2	17.4 ± 11.2†
Chronic conditions and medications			
History of arthritis‡ (%)	62.5	70.4*	73.7*
History of coronary heart disease§ (%)	15.3	29.4*	28.8*
History of stroke (%)	4.3	8.7*	14.0*
Fainted in previous year (%)	3.7	6.0*	9.4*
Dizziness upon standing (%)	18.6	25.3*	28.3*
Positive Geriatric Depression Scale score‖ (%)	4.3	8.3*	6.4
Uses medication for sleeplessness or anxiety (%)	20.7	27.9*	21.2
Physical and cognitive performance			
Any difficulty with IADLs¶ (%)	37.6	57.2*	71.0*†
Grip strength (kg)	18.8 ± 4.7	18.1 ± 4.7*	16.7 ± 4.4*†
Quadriceps strength (kg)	62.7 ± 26.6	55.4 ± 27.1*	55.2 ± 29.7*
Tandem walk score#	16.4 ± 7.8	18.5 ± 8.8*	22.0 ± 8.9*†
Poor tandem stand performance (%)	42.3	56.3*	77.5*†
Walking speed (m/s)	0.91 ± 0.22	0.81 ± 0.22*	0.73 ± 0.22*
Chair stands (s)	12.3 ± 4.8	13.7 ± 5.2*	14.3 ± 5.2*
Corrected visual acuity score‡	49.4 ± 7.2	48.4 ± 7.8*	43.8 ± 11.1*†
Contrast sensitivity score‡	57.1 ± 29.2	51.0 ± 27.3*	35.7 ± 24.2*†
Near depth perception‡ (seconds of arc)	85 ± 85	89 ± 87	117 ± 123*
Distant depth perception‡ (cm)	2.2 ± 2.6	2.4 ± 2.9	3.4 ± 3.3*†
Trails B (could not complete in 3 min) (%)	15.3	23.9*	24.3*
Digit symbol score (number correct)	43.6 ± 11.6	39.5 ± 12.0*	37.3 ± 11.3*
Peripheral neuropathy			
Vibration threshold (vibration units)	5.8 ± 2.6	6.5 ± 2.7*	8.3 ± 3.9*†
Loss of pressure sensitivity** (%)	12.2	18.8*	29.1*†

Data are means ± SD unless otherwise noted. *$P < 0.05$ compared with women without diabetes. †$P < 0.05$ compared with women with non–insulin-treated diabetes. ‡Measured at baseline. All others measured at second visit. §Heart attack, angina, or congestive heart failure. ‖Six or more symptoms on the 15-item Geriatric Depression Scale. ¶Ability to perform five instrumental activities of daily living without assistance or the use of special equipment: walking two to three blocks, climbing 10 steps, preparing own meals, doing heavy housework, and doing own shopping. #Time to complete tandem walk in seconds plus number of errors. **Could not detect monofilament smaller than 5.07 applied to toe. IADL, instrumental activity of daily living.

fallers using only the first 2 years of follow-up. In those 2 years, the proportion of women who had at least one fall was similar among those with and without diabetes (44 vs. 42%; $P = 0.26$). However, among women who fell in those 2 years, those with diabetes had more falls on average than those without diabetes (3.1 vs. 2.4 falls; $P < 0.01$).

In age-adjusted models of the entire cohort of 9,249 women, those with diabetes were at increased risk of falling more than once a year. Women with diabetes who were not using insulin had a 68% greater risk of falling more than once a year compared with women without diabetes (odds ratio [OR] 1.68 [95% CI 1.37–2.07]). Women using insulin had more than double the risk of falling more than once a year than women without diabetes (OR 2.78 [1.82–4.24]). Women with diabetes were also at increased risk of falling more than twice a year (OR 1.63 [1.22–2.18] for non–insulin-treated diabetes and OR 2.55 [1.45–4.49] for insulin-treated diabetes, compared with no diabetes). Among women with diabetes, time since diagnosis was not associated

Table 2—*Frequency of falls and proportion of fallers among older women by diabetes and insulin use*

	No diabetes	Non–insulin-treated diabetes	Insulin-treated diabetes
n	8,620	530	99
Incidence of falls (per person-year)			
70–74 years old	0.43	0.56*	1.26*†
75–79 years old	0.52	0.74*	0.82*
80–84 years old	0.66	0.89*	1.31*†
≥ 85 years old	0.98	1.32*	1.37*
All ages	0.62	0.85*	1.12*†
Fell more than once a year (%)	17.0	25.7*	35.4*†
Fell more than twice a year (%)	6.8	10.6*	15.2*
Follow-up (years)	7.2 ± 1.9	6.6 ± 2.2*	6.2 ± 2.4*

Data for follow-up are means ± SD. *$P < 0.05$ compared with women without diabetes; †$P < 0.05$ compared with women with non–insulin-treated diabetes.

Table 3—*ORs* and 95% CIs for the association between diabetes and falling more than once a year† among older women*

Covariates included in model	Non–insulin-treated diabetes‡ OR (95% CI)	Coefficient	Change in coefficient§	Insulin-treated diabetes‡ OR (95% CI)	Coefficient	Change in coefficient§
Age	1.53 (1.14–2.04)	0.42	—	3.98 (2.25–7.05)	1.38	—
Age + balance‖	1.34 (1.00–1.81)	0.30	−30%	2.98 (1.67–5.32)	1.09	−26%
Age + history of coronary heart disease	1.43 (1.06–1.92)	0.36	−16%	3.70 (2.08–6.57)	1.31	−7%
Age + history of arthritis	1.45 (1.08–1.95)	0.37	−12%	3.92 (2.21–6.95)	1.37	−1%
Age + peripheral neuropathy#	1.49 (1.11–1.99)	0.40	−6%	3.83 (2.16–6.79)	1.34	−3%
Multivariable model**	1.18 (0.87–1.60)	0.16	−61%	2.76 (1.52–5.01)	1.02	−32%

*Logistic regression models. $N = 5{,}430$. Women with missing values for any of the covariates in the multivariable model were excluded from all smaller models. †An average of more than one fall per year during follow-up. Mean follow-up time for falls was 7.2 (± 1.9) years. ‡Compared with women who did not report a history of diabetes. §Change in the logistic regression coefficient for diabetes compared with the coefficient in the age-adjusted model. ‖Tandem walk score and tandem stand (eyes open). ¶Heart attack, angina, or congestive heart failure. #Loss of pressure sensitivity. **Adjusted for age, tandem walk score, tandem stand (eyes open), loss of pressure sensitivity, history of coronary heart disease, history of stroke, history of arthritis, history of fainting, grip strength, positive Geriatric Depression Score, near depth perception, and use of medications for sleeplessness or anxiety.

with an increased risk of falling more than once a year in an age-adjusted model (OR 1.07 [0.89–1.28] for each additional 10 years).

Participants excluded from the multivariable model ($n = 3{,}819$) because of missing values were somewhat more likely to have diabetes (7.6% of excluded participants vs. 6.3% of those included) and to have fallen at least once a year (20 vs. 16%). However, the associations between diabetes and falling in age-adjusted models restricted to the participants without missing information ($n = 5{,}430$) (OR 1.53 [1.14–2.04] for non–insulin-treated diabetes and OR 3.98 [2.25–7.05] for insulin-treated diabetes, both compared with no diabetes) were similar to the results reported above ($n = 9{,}249$).

At the fourth visit, an additional 73 women reported a diagnosis of diabetes or the use of hypoglycemic medications. Nine women reported insulin use who had diabetes at baseline but were not being treated with insulin. Excluding these 82 women from the age- and multivariable-adjusted models did not substantially alter the associations between diabetes and falling more than once a year (results not shown).

Poor balance

Of the risk factors for falls retained in the multivariable model, the tandem walk, a measure of dynamic balance, accounted for the largest percentage (23%) of the association between non–insulin-treated diabetes and falling. Poor performance on the tandem stand (eyes open), a measure of static balance, accounted for 14% of the association between non–insulin-treated diabetes and falling. Together, these two balance measures accounted for 30% of the association between non–insulin-treated diabetes and falling and 26% of the association between insulin-treated diabetes and falling (Table 3).

Other risk factors for falls

The other risk factors for falls that accounted for 10% or more of the association between non–insulin-treated diabetes and falling were history of heart disease (16%) and history of arthritis (12%). For insulin-treated diabetes, history of heart disease attenuated the association with falling by 7% and history of arthritis by 1%.

Peripheral neuropathy

Falling more than once a year was associated with decreased vibration sensitivity (age-adjusted OR 1.12 [1.05–1.19] for 1 SD increase in vibration threshold) and loss of pressure sensitivity (age-adjusted OR 1.58 [1.34–1.87]). Loss of pressure sensitivity was independently associated with the risk of falling more than once a year and accounted for 3–6% of the relationship between diabetes and falling.

Multivariable adjustment

The association between non–insulin-treated diabetes and falling was substantially reduced and was no longer statistically significant after controlling for multiple factors (OR 1.18 [0.87–1.60]). Adjusting for multiple factors accounted for 61% of the association between falling and non–insulin-treated diabetes (Table 3). These factors accounted for a smaller portion (32%) of the association between diabetes and falling in women using insulin, and the association remained statistically significant (OR 2.76 [1.52–5.01]).

CONCLUSIONS — We found an elevated risk of falling among older women with diabetes, particularly among those using insulin. Previous studies of falls and diabetes have produced mixed results. In the Third National Health and Nutrition Examination Survey, diabetes was a risk factor for falls and injurious falls in older women (6). Similarly, a study of African-American men and women aged ≥70 years reported an elevated risk of falling among individuals with diabetes (7). The Rotterdam Study, however, found no association among women aged ≥55 years (8). An increased risk of serious injury due to a fall was reported among diabetic adults in Finland (21), but a study of fall injuries among older adults in Florida found no association with diabetes (22).

Most studies of falls have followed participants for 1 or 2 years, compared with an average of >7 years of follow-up reported here, and may therefore not have detected an increased risk of falling in diabetic women. In addition, analyses of falls often consider the proportion of fallers rather than the rate of falls. In our first 2 years of follow-up, we found little difference in the proportion of fallers between those with and without diabetes. However, among those who fell, diabetes was associated with more frequent falls.

Our results suggest that poor balance is a factor in the causal pathway between diabetes and increased risk of falling. Although poor balance has been previously identified as a risk factor for falls among older women (23), results in diabetic women are limited (24). Lord et al. (25) in a study of older women in Australia reported that individuals with diabetes had increased body sway. However, Miller et al. (7) found no consistent association with diabetes and measures of balance among older African-American women. Others have reported that postural instability was only increased in individuals with diabetes who also had peripheral neuropathy (26,27).

Loss of pressure sensitivity, a measure of peripheral neuropathy, accounted for 3–6% of the association between diabetes and risk of falling. Richardson and Hurvitz (28) identified peripheral neuropathy, measured as nerve conduction velocity, as a risk factor for falls. Studies in older adults with and without diabetes have found that peripheral neuropathy is associated with reduced balance and walking speed (29). We found that loss of pressure sensitivity was independently associated with falling. However, the association was modest and thus did not substantially account for the increased risk of falling among individuals with diabetes. Measures of nerve conduction velocity were not available to us.

Other factors that accounted for more than 10% of the association between fall risk and diabetes were history of coronary heart disease and arthritis. Arthritis is an established risk factor for falls, whereas coronary heart disease and fall risk have been less consistently associated in previous studies (30).

The risk factors for falls that were evaluated for this cohort accounted for most (61%) of the association between diabetes and falling among women who were not using insulin. Among women using insulin, the measures available to us accounted for a smaller but still substantial percentage (32%) of the association between diabetes and falling. The inability to account for a greater portion of the association in women using insulin may have several explanations. Effects of insulin treatment, such as episodes of dizziness or fainting, may lead to an increased risk of falls. We found that women using insulin were more likely to report episodes of fainting, although this did not account for their increased risk of falling. However, participants were not asked if their falls were associated with an episode of hypoglycemia. Participants receiving insulin may have a higher likelihood of complications such as nocturia, which may increase the risk of falling, but these complications were not measured in the Study of Osteoporotic Fractures. Finally, there may be risk factors that are particularly important in accounting for the association between diabetes and falls among individuals using insulin that were measured with inadequate precision.

The increased fall risk found in our study suggests that fall prevention efforts need to be incorporated into treatment of older women with diabetes. This is particularly important given the growing evidence, from this cohort (2) and other studies (3,4), that older women with diabetes have a higher risk of fracture.

Research to date has not considered the effectiveness of improved glycemic control for preventing falls. Measures of glycemic control were not available to us; therefore, we could not assess its association with falling. Our finding that comorbidities associated with diabetes account for a substantial percentage of the higher risk of falling, especially for individuals not using insulin, suggests that improved glycemic control may reduce fall risk. This issue will require further investigation because it is also possible that tighter control may increase episodes of hypoglycemia and thus the risk of falling.

Our study has several limitations. Because diabetes was determined by self-report in this study, those participants identified as not having diabetes may have included women with undiagnosed diabetes. However, such misclassification would tend to weaken any association between diabetes and falling. In addition, the participants in this study were volunteers, community-dwelling ambulatory women, and mainly white. Our results may not apply to the broader population of older women, especially those in institutions, or to older men. This study has several important strengths. Falls were determined prospectively in a large cohort over an extended period of follow-up. Measurements were available on many risk factors for falls that are also associated with diabetes, including vision, peripheral neuropathy, and functional status.

These results indicate that older women with diabetes, especially those using insulin, have a substantially increased risk for falls. This increased risk is due in part to a higher prevalence of previously identified risk factors for falls among women with diabetes, including poor balance, arthritis, cardiovascular disease, depression, poor vision, and use of medications for sleeplessness or anxiety. Our findings suggest that fall prevention efforts should be a consideration in the treatment of older women with diabetes. Further research is needed to evaluate whether improved treatment of diabetes can reduce fall risk.

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