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Dietary Protein and Vitamin D Intake and Risk of Falls: A Secondary Analysis ofPostmenopausal Women from the Study of Osteoporotic Fractures

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Abstract

More than 90% of hip fractures in older Americans result from a fall. Inadequate intake of dietary protein and vitamin D are common in older adults, and diets in low these could contribute to loss of muscle mass and strength or coordination, in turn increasing the risk of falling. The objective of the study was to evaluate the relationship between protein and vitamin D intake with the occurrence of falls in older women in the Study of Osteoporotic Fracture, a prospective cohort of more than 4000 postmenopausal women participating from January 1997 to September 1998.

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Incident falls were ascertained for one year. Protein and vitamin D intake was assessed by a food frequency questionnaire; associations with a reported fall were estimated with logistic regression, adjusted for fall-related covariates and energy. Protein and vitamin D were modeled separately because of high correlation (rho=0.55, P<0.001). A total of 1429 women reported a fall within one year. In separate, unadjusted models dietary protein (per 1 g/kg increase) and vitamin D (per 100 International Unit (IU) increase) significantly increased the odds ratio (OR) of falling (OR 1.35 95% CI 1.15–1.59, OR 1.11 95% CI 1.03–1.19, respectively). Once fall-related covariates were added to each model, dietary protein and vitamin D were noncontributory to falls. While we could find no direct association between vitamin D and protein intake and fall prevention, adequate intake of these two nutrients are critical for musculoskeletal health in older adults.

Keywords

dietary intake; *health outcomes*; *older women*

INTRODUCTION

Falls are frequent among older adults; one out of three individuals aged 65 years and older fall each year (1). Older women are at increased risk, and two-thirds of those who fall once will do so again within six months (2). Falls are also highly linked with serious injury; they are the leading cause of fractures. Indeed, nine out of ten hip fractures in older Americans result directly from a fall (3). Fractures, especially hip fractures, are associated with significant morbidity and mortality; one of four will die within a year of experiencing a hip fracture (4). Besides age and gender, factors that are known to increase the risk of falling include prior history of falls, reduced muscle strength, balance impairment, visual impairment, multiple medication use, depression, functional limitations, cognitive impairment, physical activity, and low body mass index (BMI) (1, 5–8). Hence, falls are a major concern for older adults, and effective preventative measures are central to health and longevity.

In general, nutrition has not been widely studied in relation to falls. Few studies have linked poor nutritional status with falls (9–10). The possible association between dietary protein and falls has been overlooked. To date, only one known prospective cohort study looked at the association of protein intake and fall risk (11). Dietary protein may affect fall incidence through its ability to affect muscle mass and function. Since adequate protein intake is needed to optimize muscle health (12), it may favorably impact muscle strength, which is a major risk factor of falls (13). Insufficient consumption of dietary protein is common in older individuals; between 32% and 41% of women aged 50 years and older consume less than the Recommended Dietary Allowance (RDA) (14). Therefore, a diet low in protein could contribute to the loss of muscle mass and strength, and partly explain the high incidence of falls in older adults.

Recently, dietary vitamin D intake is an area of investigative interest in fall pathogenesis and prevention. Despite this vitamin's importance, deficiency and insufficiency are prevalent in older Americans as a consequence of inadequate dietary intake, minimal sunlight exposure, impaired intestinal absorption, medication use, and enterohepatic recirculation (15). All this notwithstanding, it remains unclear if supplementation with vitamin D significantly reduces the risk of falling. Some studies have reported an inverse relationship between vitamin D status and intake and fall risk (16–18), while others have shown no relationship (19).

The primary purpose of our analysis was to evaluate the association between dietary protein and subsequent falls in a sample of postmenopausal women from the Study of Osteoporotic Fractures (SOF). Second, we wanted to examine both serum vitamin D status and dietary vitamin D intake with falls. We hypothesized that increased dietary protein and vitamin D would be independently associated with decreased risk of falling over a one-year period in both unadjusted models and models adjusted for potential confounders.

METHODS

Subjects

Participants are from SOF, an observational study of postmenopausal women that includes prospective data on bone health and aging (20). Enrollment began in 1986 in four U.S. clinical centers, and clinical visits occurred approximately every two years. A total of 9704 Caucasian women older than 65 years were enrolled when the study began.

For the purpose of our study, data from visit 6 (V6, years 1997–1998) were utilized because 4886 participants completed the Block Food Frequency Questionnaire (FFQ) (20); V6 data are considered "baseline." The Block FFQ consisted of 109 food items and included questions on alcohol intake and vitamin and mineral supplementation including calcium. A slightly modified version of this FFQ was found to have moderate to high reliability and validity (21).

Predictor Variables

Protein intake from any source was analyzed by the FFQ as grams per day (g/day), which we converted to grams per kilograms body weight (g/kg) to compare subjects' intakes with the RDA for protein, 0.8 g per kg. Daily intake (IU/day) through diet and average supplemental vitamin D and calcium (mg) were estimated from the FFQ. The unadjusted associations with falls were analyzed separately for total daily intake, dietary and supplementary vitamin D to determine which would have the strongest association with falling. In addition, a subset of women (N=1,171) were randomly chosen to have their visit 6 serum 25-hydroxyvitamin D [25 (OH) D] measured as nano-grams per milliliters (ng/ ml). Complete details of the methodology of serum 25 (OH) D measurement and collection are shown elsewhere (22).

Primary Outcome Variable

Falls, the primary outcome variable, was examined prospectively one year post-V6 and treated as a dichotomous variable. Fall incidence was captured by postcard and telephone calls every four months. Subjects were asked, "During the past four months, have you fallen and landed on the floor or ground, or fallen and hit an object like a table or stair (or chair)?" and, if so, how many times (6, 23). Falls were defined as "landing on the floor or ground, or falling and hitting an object like a table or a chair." For fall data, only incidences of falls were examined and they were not distinguished as injurious or noninjurious.

Fall-Related Risk Factors

Candidate fall-related covariates, collected during the clinical V6, that were previously shown to be associated with falls included history of a previous fall (yes/no); age; number of alcoholic drinks per week; depressive symptoms (assessed by the Geriatric Depression Scale score on a 15-point scale dichotomized with ≥ 6 indicating a higher level of depressive symptoms) (24); number of items out of six Instrumental Activities of Daily Living with reported difficulty in completing tasks including walking two to three ground level blocks, climbing up and/ or down 10 steps, preparing own meals, doing housework, and shopping; count of total medications (nonprescription and prescription) (25); average of right and left isometric handgrip strength (kg); BMI; current smoking status (yes/no); number of hours of sleep per night; visual acuity of 50 or better for both eyes; and cognitive function (score on Short Mini Mental Status Exam). Physical activity factors included four variables: (1) self-reported number of blocks walked per day for exercise or during normal routine/ nonexercise; (2) estimated calories burned per week from walking; (3) number of hours standing on feet daily; and (4) estimated number of hours spent with "feet up" (including when trying to sleep, watching television laying on a sofa) or number of hours "sitting upright" (at the table eating, driving or riding in a car, sitting while watching television or talking). Subjects self-rated their health by answering the following questions: "Compared with others your own age, how would you rate your overall health?" which was based on a 5-point scale from 1—excellent to 5—very poor, and, "Compared to 12 months ago, how would you rate your overall health?" which was based on a 5-point scale ranging from 1—much better to 5—much worse.

Statistics

For descriptive purposes women were divided into below RDA for dietary protein (<0.8 g/kg/d) or meets RDA for dietary protein (≥0.8 g/kg/d) groups; and below RDA for vitamin D (<800 IU) or meets RDA for vitamin D (≥800 IU). Baseline characteristics were compared using either ANOVA or chi-square for continuous and categorical data, respectively; means and ±1 standard deviation or percentages were reported.

To assess dietary protein and vitamin D's impact on fall risk, along with already published fall risk factors, unadjusted logistic regression was used to calculate the odds ratio and 95% confidence intervals [OR (95%CI)] for the occurrence of a fall (yes/no) within one year after V6 per 1 g/kg or per 50 g/day increase in protein intake and for vitamin D per 100 IU increase in dietary vitamin D or per 1 ng/ mL increase in the serum 25(OH)D. Quadratic regression was performed to assess if there was a curvilinear or linear association between falls and dietary protein and falls and vitamin D. Because the high correlation between dietary protein (g/kg) and vitamin D intake (IU/d) (rho=0.55, $P<0.001$) results in collinearity, which would bias point and variance estimates, they were analyzed in separate models. Once each predictor of interest (dietary protein and vitamin D) was added into its own model, to control for confounding we used forward stepwise selection of fall-related variables previously listed. Forward stepwise regression only allows entry into the multivariable model if a candidate variable met an α level of 0.05 for its association with falling. Vitamin D and protein were forced into their respective models in order to observe their odds ratios and 95% confidence intervals in the final steps.

Finally, dietary protein and vitamin D were adjusted by energy by dividing protein (g/day) by kcal, and vitamin D (IU) by kcal (26). We repeated the forward stepwise selection process with these energy-adjusted variables forced in and all significant potential fall-related confounders selected. Analyses were repeated with protein as grams per day (g) and with quartiles of: protein (g/kg), vitamin D (IU), and serum 25 (OH) D (ng/mL).

Subjects with missing data were excluded. All analyses were conducted with PASW Statistics, version 18.0 (SPSS, Inc.) and two-sided tests with $P<0.05$ were considered statistically significant.

RESULTS

Participant Characteristics

Baseline characteristics of the participants were compared between those whose dietary protein is below the RDA versus those who meet the RDA (Table 1). Sixty-two percent of participants consumed the RDA for protein or higher. Individuals with protein intakes that met the RDA also consumed more total calories, vitamin D, and calcium; were older; and had lower BMIs and lower average grip strength compared to persons with protein intakes below the RDA ($P<0.05$). Women with higher protein intakes (≥0.8 g/kg) were also more likely to have a higher prevalent history of falls compared to women with lower protein intake ($P=0.043$), walk for exercise, walk more blocks during daily routine, and to have burned more calories from walking ($P<0.001$). In addition, fewer women admitted to spending less than or equal to four hours on their feet per day than the group below the RDA, but this was only borderline significant ($P=0.051$). All other factors were nonsignificant. Table 2 presents baseline characteristics of participants with the RDA of total dietary vitamin D intake, where only 56 participants had total dietary vitamin D intake meeting the RDA (≥800 IU). Not surprisingly, women who met RDA of total dietary vitamin D intake also consumed more total calories and protein intakes. However, they also took more medications and walked more blocks during daily routine.

Results of the Unadjusted Regression Models

Of the 4369 women included in the regression model, 1429 (33%) reported at least one fall within 12 months following V6. Higher dietary protein, per 1 g/kg increase was found to be significantly associated with an increased risk of falling in unadjusted regression ($P<0.001$) with OR (95%CI) of 1.35 (1.15–1.59). Likewise, when dietary protein was expressed as g/day, the odds of falling increased by about 22% for every 50 g per day increase in protein intake. Quartile analyses indicated the third highest and highest categories of protein intake (g/kg) increased falling in comparison to those with the lowest protein intake [1.26 (1.06–1.51), $P=0.01$; 1.34 (1.12–1.59), $P=0.001$].

Similar to dietary protein, in unadjusted logistic regression, the odds of falling were 1.11 (1.03–1.19) for each 100 IU increase in dietary vitamin D intake ($P=0.002$). However, no association was observed with falls and either total daily intake of vitamin D (0.06) or average daily supplemental vitamin D in the entire sample (P=0.55), and thus were dropped from additional analyses. Only the third quartile of dietary vitamin D intake was associated with increased risk of falls by approximately 19% in relation to the lowest quartile (P=0.049). Finally, the quadratic regression terms for dietary protein and vitamin D were not significant indicating linear relationships between falls with dietary protein and with vitamin D (IU) were appropriate.

Subset with Serum Vitamin D Levels

In the subset of N=1157 where serum 25-hydroxyvitamin D was measured (mean 25.13 ng/mL; range: 6–110 ng/mL), there was no association between falls and serum vitamin D as a continuous variable (P=0.87); nor was serum vitamin D associated with falls when divided into quartiles.

Dietary Protein, Vitamin D, and Falls in Adjusted Models

When all significant fall-related covariates were added to the final forward stepwise regression models, protein and dietary vitamin D were no longer associated with falls (Table 3). Of note, calcium was not selected possibly due to its low correlation with falling (P=0.04). When dietary protein and vitamin D were adjusted for energy intake, they continued to be nonsignificant (Table 3). In quartile analyses, neither protein nor vitamin D remained significant in the final step.

DISCUSSION

In this prospective analysis of more than 4000 women using unadjusted logistic regression, dietary protein and vitamin D were positively associated with increased risk of falling. With the addition of covariates known to be associated with falls, and in separate models, protein and vitamin D no longer contributed to the odds of falling. To our knowledge, there is only one study directly examined protein intake and fall incidence. In a prospective study with 807 male and female participants (mean age 75 years) in the Framingham Study, Zoltick and colleagues (11) studied how dietary protein adjusted for total energy intake dietary calcium, calcium supplement use, dietary vitamin D, and weight loss affected risk of falling. Occurrence of falls (yes/no) was assessed at baseline and one-year follow-up. Similar to our study, falls were recorded regardless of an injury. Two main differences between our study and Zoltick and colleagues' study are they stratified their analyses by weight loss versus no weight change and 37% of their cohort were men. The authors theorized that a weight loss of ≥ 5% body weight at follow-up would be a potential effect modifier since unintentional weight loss is associated with increased risk of falling (11). They found some benefit of moderate protein intake on falls over a one-year period. The rate ratios for falls indicated protective effects of each type of protein intake (total, animal, vegetable), although they were not statistically significant (P>0.05). Total and animal protein intakes were significantly protective of falling in subjects who lost weight versus those who did not lose ≥5% of their weight, although there was no mention if the authors performed a test for interaction to observe this difference between the subgroups. There also was no association between protein intake and falls with weight maintenance (11).

Their lack of significant findings outside weight changes is consistent with our observations that dietary protein does not affect falls. The inverse link between protein intake and risk of falling with weight loss indicates further research is needed.

Our results are surprising as higher protein intake is associated with increased lean body mass, thus one might predict less susceptibility to falling. Diets higher in protein in older adults may be protective against sarcopenia (27). Close to one-third of adults 60 years or older have sarcopenia and the incidence increases to more than 50% for adults older than 80 years (27). These individuals with lower muscle mass are at risk of being frail and in combination with a slow, unsteady gait, and loss of strength, the risk of falling greatly increases (28). Houston and colleagues (13) examined the association of protein intake with lean body mass over a three-year period in 2066 older men and women (mean age 74.5 years) participating in the Health, Aging, and Body Composition Study. Those with the highest protein intake (divided into quintiles) lost 43% less lean mass than those who consumed the lowest amount (P<0.01). Given that muscle mass and strength (measured as hand grip strength) are positively correlated (29), we predicted that grip strength would be higher in the high dietary protein group. The fact that grip strength was higher in the lower protein individuals (Table 1) contradicted our predictions.

While protein as a predictor of falls has received little attention there has been more consideration and, subsequently more controversy, over the relationship between vitamin D and falls. There are multiple randomized control trials that studied supplemental vitamin D's possible role in fall prevention. However, the results are inconsistent. Reviews and meta-analyses involving vitamin D and fall prevention were generally positive (17–18), although one concluded that calcium supplementation was required (19). A 2007 review by the Agency for Healthcare Research and Quality examined both serum 25 (OH) D and supplemental vitamin D's impact on falls (16). It was concluded that in institutionalized older adults, there is a reduced risk of falling in individuals with higher serum 25 (OH) D, especially if the value is below 40–80 nmol/L (16–32 ng/ mL). It should be noted that only 23% of the subset with serum 25 (OH) D measures were higher than 32 ng/ mL; when considering the Institute of Medicine's guidelines of ≥20 ng/mL as adequate for bone and overall health in healthy individuals 70% of our sample met this criteria (30). Therefore, since most of our subset is not vitamin D deficient and can be considered overall relatively healthy (and were not institutionalized), it is not surprising we did not find an association between falls and 25 (OH) D. Additionally, with supplemental vitamin D the results were inconsistent as to whether it leads to a reduction in falls. Our study also saw no significance with supplemental vitamin D (IU) and falls in one year; longer follow-up time and a group at higher risk for vitamin D deficiency may be necessary to observe significant effect of vitamin D on falls.

Strengths of the current study include its large sample size and its comprehensive set of fall risk factors. SOF investigators contacted subjects through postcards and phone calls every four months, which greatly increases accuracy in comparison to annual reporting. Limitations include that we were not able to differentiate injurious from noninjurious falls. There is the possibility that participants with higher protein and vitamin D intake incurred less injuries from falls. We used RDA as the cutoff instead of Estimated Average

Requirement, which may result in different outcomes. The women were mostly Caucasian so study findings may not apply to non-White women or men. Last, it is possible that one year was not a long enough time to capture an association with nutrition and falls.

In summary, this study of more than 4000 older women did not find dietary protein and vitamin D to be predictors of subsequent falls over a one-year period after adjusting for fall-related risk factors. While we could find no direct association between vitamin D and protein intake and fall prevention, adequate intake of these two nutrients are critical for musculoskeletal health in older adults.

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TAKE AWAY POINTS

- In older individuals, published data on vitamin D intake and falls are conflicting. Data on dietary protein intake and falls are limited.
- In a large group of postmenopausal women, neither dietary protein nor vitamin D were predictors of falls over a one-year period (after adjusting for fall-related risk factors).
- Although achieving adequate vitamin D and protein in the diets of older women is clearly important for the musculoskeletal system, these nutrients may not directly contribute to the prevention of falls.

TABLE 1

Baseline Characteristics of Participants Stratified by Not Meeting the RDA for Dietary Protein (<0.8 g/kg Body Weight) versus Meeting RDA (≥ 0.8 g/kg)

Sample characteristics	Dietary protein below RDA (*N*=1,756)[a]	Dietary protein meets RDA (*N*=2,889)	*p*-value
Dietary Protein (g/kg)[b]	0.6±0.1	1.2±0.3	<0.001
Dietary Protein (g)	42.6±10.8	71.6±18.4	<0.001
Vitamin D Intake (total IU)	291.3±206.9	387.7±223.9	<0.001
Calcium Intake (mg)	540.4±231.0	908.1±381.0	<0.001
Daily Calories (Kcal)	1,115.6±281.5	1,647.9±424.3	<0.001
Age (Years)	79.8±3.9	80.4±4.3	<0.001
BMI (kg/ M^2)	28.2±4.7	25.4±4.0	<0.001
Smoking Status (*N* (% yes))[c]	67 (3.8)	121 (4.2)	0.5
History of falls (*N* (% yes))	519 (29.6)	935 (32.4)	0.04
Average Grip Strength (kg)	17.0±4.1	16.7±4.1	0.01
Cognitive Function (sMMSE score, range 0–26)	24.1±2.3	24.1±2.2	0.8
Medications (total number)	3.0±1.9	3.2±2.0	0.004
Vision Acuity >50 (*N* (% yes))	31 (18.7)	484 (17.5)	0.4
Alcohol use (drinks/ day)	1.30±3.1	1.3±3.1	0.9
Geriatric Depression Scale Score (*N* (% score >6))	149 (8.5)	232 (8.0)	0.6
Difficulty with 6 IADLs (total difficulty, range 0–18)	2.3±3.8	2.2±3.7	0.2
Self-rated health status- compared to 12 mo ago (*N* (% reported good to excellent))	242 (13.8)	458 (15.9)	0.1
Health compared to others (*N* (% report somewhat better to better)	1397 (79.6)	2315 (80.1)	0.6
≤ 4hours on feet per day (*N* (% yes))	250 (14.3)	354 (12.3)	0.1
Kcals per week burned from walks (kcal)	501.0±620.5	596.0±646.1	<0.001
Walk for exercise (*N* (%yes))	600 (34.3)	1264 (43.8)	<0.001
Blocks walked per day (number walked for exercise)	10.0±8.8	11.2±8.6	0.3
Blocks walked per day (number walked non-exercise)	5.2±6.4	5.7±6.4	0.02
Hours per day with feet up (hours)	8.4±2.0	8.5±1.9	0.3
Hours per day sitting up (hours)	7.5±3.5	7.4±3.3	0.6

[a] *N* represents the total sample size for the RDA of protein. All those with missing data were excluded.

[b] Continuous variables are presented as mean±standard deviation.

[c] Dichotomous variables are presented as sample size and percentages.

TABLE 2

Baseline Characteristics of Participants Stratified by Not Meeting the RDA for Dietary Vitamin D (<800 IU per Day for People >70 Years Old) versus Meeting RDA (800 IU)

Sample characteristics	Dietary vitamin D below RDA (*N*=4,829)[a]	Dietary vitamin D meets RDA (*N*=56)	*p*-value
Dietary Protein (g/kg)[b]	0.9±0.4	1.6±0.5	<0.001
Dietary Protein (g)	60.0±20.6	103.7±26.7	<0.001
Vitamin D Intake (total IU)	343.3±214.9	908.2±83.8	<0.001
Calcium Intake (mg)	753.0±353.4	1,940.6±382.0	<0.001
Daily Calories (Kcal)	1,437.9±447.8	2,116.1±677.8	<0.001
Age (Years)	80.2±4.2	79.7±4.0	0.3
BMI (kg/ M^2)	26.4±4.6	26.7±4.5	0.7
Smoking Status (*N* (% yes))[c]	193 (4.0)	7 (12.5)	<.001
History of falls (*N* (% yes))	1517 (31.5)	20 (35.7)	0.5
Average Grip Strength (kg)	16.8±4.2	17.4±4.1	0.3
Cognitive Function (sMMSE score, range 0–26)	24.1±2.3	24.2±2.1	0.6
Medications (total number)	3.1±1.9	4.00±2.0	0.001
Vision Acuity >50 (*N* (% yes))	818 (17.9)	10 (17.9)	1.0
Alcohol use (drinks/ day)	1.3±3.1	1.0±2.7	0.5
Geriatric Depression Scale Score (*N* (% score >6))	407 (8.4)	8 (14.3)	0.1
Difficulty with 6 IADLs (total difficulty, range 0–18)	2.4±3.9	2.1±3.6	0.6
Self-rated health status- compared to 12 mo ago (*N* (% reported good to excellent))	721 (14.9)	9 (16.1)	0.8
Health compared to others (*N* (% report somewhat better to better)	3830 (79.3)	39 (69.6)	0.1
≤ 4hours on feet per day (*N* (% yes))	657 (13.6)	9 (16.1)	0.6
Kcals per week burned from walks (kcal)	549.9±633.7	692.0±830.0	0.1
Walk for exercise (*N* (%yes))	1907 (39.6)	26 (46.4)	0.3
Blocks walked per day (number walked for exercise)	11.0±8.6	15.0±13.0	0.02
Blocks walked per day (number walked non-exercise)	5.5±6.4	5.4±6.1	0.9
Hours per day with feet up (hours)	8.5±2.0	8.6±2.6	0.7
Hours per day sitting up (hours)	7.5±3.4	7.1±3.7	0.4

Note. Total dietary vitamin D is presented in the table.

[a]*N* represents the total sample size for the RDA of vitamin D. All those with missing data were excluded.

[b]Continuous variables are presented as mean±standard deviation.

[c]Dichotomous variables are presented as sample size and percentages.

TABLE 3

Final Dietary Protein and Vitamin D Models and Their Associations with Any Falls (Yes/No) One Year after Visit 6 with and without Adjustment for Energy from Multivariable Logistic Regression

	Risk factor	Odds ratio	95% CI	*P*-value
Protein	Protein (per 1 g/kg)	1.2	0.9–1.6	0.2
	History of Falls	2.2	1.8–2.8	<0.001
	Age (per 1 year increase)	1.1	1.0–1.1	<0.001
	Depressive Symptoms*	1.6	1.0–2.6	0.03
	Medication (per 1 unit increase in total number)	1.1	1.0–1.1	0.04
	≤ 4hours on feet per day*	1.6	1.1–2.3	0.01
	Difficulty with 6 IADLs (per 1 point increase in score, range 0–18)	1.1	1.0–1.1	0.04
Model Adjusted for Energy	Protein (per 1 g/ kcal) × 100	1.0	0.9–1.2	0.9
	History of Falls*	2.2	1.8–2.8	<0.001
	Age (per 1 year increase)	1.1	1.0–1.1	<0.001
	Depressive Symptoms*	1.6	1.1–2.6	0.03
	Medication (per 1 unit increase in total number)	1.1	1.0–1.1	0.03
	≤ 4hours on feet per day*	1.6	1.1–2.3	0.01
	Difficulty with 6 IADLs (per 1 point increase in score, range 0–18)	1.1	1.0–1.1	0.04
Vitamin D	Vitamin D (per 1 IU)	1.0	1.0–1.0	0.3
	History of Falls*	2.2	1.7–2.7	<0.001
	Age (per 1 year increase)	1.1	1.0–1.1	<0.001
	Depressive Symptoms*	1.7	1.1–2.6	0.03
	Medication (per 1 unit increase in total number)	1.1	1.0–1.1	0.03
	≤ 4hours on feet per day*	1.6	1.1–2.2	0.01
	Difficulty with 6 IADLs (per 1 point increase in score, range 0–18)	1.1	1.0–1.1	0.03
Model Adjusted for Energy	Vitamin D (per 1 IU)/ kcal) × 100	1.0	1.0–1.0	0.8
	History of Falls*	2.2	1.7–2.7	<0.001
	Age (per 1 year increase)	1.1	1.0–1.1	<0.001
	Depressive Symptoms*	1.7	1.1–2.6	0.03
	Medication (per 1 unit increase in total number)	1.1	1.0–1.1	0.03
	≤ 4hours on feet per day*	1.5	1.1–2.2	0.01
	Difficulty with 6 IADLs (per 1 point increase in score, range 0–18)	1.1	1.0–1.1	0.03

*Indicate dichotomous variables.

**Candidate variables: history of a previous fall, age, number of alcoholic drinks per week, calcium intake (mg), depressive symptoms, number of items out of 6 IADLs with reported difficulty in completing tasks, average of right and left isometric handgrip strength (kg), BMI, current smoking status (yes/no), number of hours of sleep per night, visual acuity of 50 or better for both eyes, cognitive function, self-reported number of blocks walked per day for exercise or during normal routine/ non-exercise, estimated calories burned per week from walking, numbers of hours standing on feet daily, estimated number of hours spent with feet up, number of hours sitting upright, subjects self-rated their health.