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Research Article

A Regression Tree for Identifying Risk Factors for Fear of Falling: The International Mobility in Aging Study (IMIAS)

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Abstract

Background: We determine the best combination of factors for predicting the risk of developing fear of falling (FOF) in older people via Classification Regression Tree (CaRT) analysis.

Methods: Community-dwelling older adults living in Canada, Albania, Brazil, and Colombia were from International Mobility in Aging Study (IMIAS). In 2014, 1,725 participants (aged 65–74) were assessed. With a retention rate of 81%, in 2016, 1,409 individuals were reassessed. Risk factors for FOF were entered into the CaRT: age, sex, education, self-rated health, comorbidity, medication, visual impairment, frailty, cognitive deficit, depression, fall history, Short Physical Performance Battery (SPPB), walking aid use, and mobility disability measured by the Nagi questionnaire.

Results: The classification tree included 12 end groups representing differential risks of FOF with a minimum of two and a maximum of five predictors. The first split in the tree involved impaired physical function (SPPB scores). Respondents with less than 8 in SPPB score and mobility disability had 82% risk of developing FOF at the end of 2-year follow-up. Between 23.2% and 82.3% of the risk of developing FOF in 2 years of follow-up were explained by only five variables: age, sex, self-rated health, functional impairment measured by SPPB, and mobility disability. In those with no functional impairment or mobility disability, levels of education, sex, and self-rated health were important predictors of FOF in the future.

Conclusion: This classification tree included different groups based on specific combinations of a maximum of five easily measurable predictors with emphasis on impaired physical functioning risk factors for developing FOF.

Keywords: Fear of falling, Risk factors, Logistic regression tree

Fear of falling (FOF), defined as enduring concerns about future falling, is usually a psychological consequence of previous falls but is also common in older adults with no history of falls (1). In either case, it prevents people from daily activities that they are normally capable of performing (2). Once FOF develops in older adults with already limited abilities, it is likely to persist independently of the occurrence of a fall event (3) and remains the strongest predictor of the first fall (4). Recently, FOF has been recognized as an independent health problem threatening the autonomy of older adults even in those with no history of falls (5). Due to inconsistent measurement methods of FOF and inclusion of different populations, there are considerable variations in prevalence rates of FOF in older adults (6). A systematic review of 28 studies reported a range of 3%–85% for prevalence but a much narrower range (21%–39%) for incidence rates of newly formed FOF after a fall event. Even with no fall during follow-up, 11.6%–23.3% of older persons reported new concerns about falls (5).

FOF is associated with adverse consequences such as falling, mobility or activity restriction, development of deconditioning, reduced social interactions, depression, and poor quality of life (3,5). A recent systematic review of 20 studies identified many sociodemographic, clinical, physiologic, and psychological factors to be associated with FOF (7). Identification of factors associated with FOF is a crucial step in finding persons at higher risks of developing FOF and also for recognition of components that should be included in an intervention program.

Traditional analytic approaches such as multivariate logistic regression are the most commonly used methods for simultaneous analysis of the influence of one or several risk factors on FOF (1,3) Classification and regression tree (CaRT) is an analytic technique that simultaneously processes large numbers of predictor variables and quantifies the relationships between these independent variables (8). Being a nonparametric approach, CaRT calculates FOF risks within a sample with its own set of FOF risk factors and permits identification of the profile of older adults who are at the highest risk of developing FOF. Furthermore, this method is useful for exploratory research by uncovering relationships between variables that are not amenable to traditional linear regression analyses (9).

To the best of our knowledge, CaRT analysis has not been applied in the investigation of FOF risk factors in longitudinal studies of community-dwelling older people. The aim of this study was to identify the most pertinent risk factors to predict risk of FOF in older people from different cultural and social backgrounds using a classification and regression tree method.

Methods

Participants

For this analysis, we used data from second (2014) and third (2016) waves of the International Mobility in Aging Study (IMIAS). IMIAS is a population-based longitudinal study of 1,995 men and women community-dwelling older adults aged 65–74 years from five sites with different social and cultural context: Kingston (Ontario, Canada), Saint-Hyacinthe (Quebec, Canada), Tirana (Albania), Manizales (Colombia), and Natal (Brazil). The aim of IMIAS is to understand how life-course factors affect mobility status. Rationale and detailed methodology of IMIAS have been described elsewhere (10). Briefly, in each site, 400 community-dwelling adults (200 men and 200 women) were included in baseline (2012) data collection. The first follow-up was conducted in 2014 with 14% attrition (58 deaths, 226 lost to follow-up). The final 2016 follow-up included 1,409 individuals representing a retention rate of 81% from 2014 (53 deaths; 263 lost to follow-up). For the present study, only data collected in 2014 and 2016 were used.

Measurement of Fear of Falling

We used the validated Falls Efficacy Scale–International (FES-I) to measure FOF. Including 16 Likert style questions about concerns for falling (1 = "not at all concerned" to 4 = "very concerned"), this instrument quantifies FOF in a range between 16 and 64 (11). As per precedents (12), we defined three levels of FOF: "no/low (16–19)," "moderate (20–27)," and "high (>27)," with higher scores indicating greater concern.

Risk Factors for Fear of Falling

Potential predictors of FOF were selected based on relevant literature (5,7) and included demographic factors, such as age, sex, living arrangements, and education, and individual risk factors, such as self-rated health (SRH), number of chronic conditions, medication use, visual impairment, frailty, cognitive function, depression, fall histories including recurrent and injurious falls, physical performance, walking aid use, and mobility disability.

Education was measured by asking about the number of years of schooling. Participants were asked if they were living alone, and in the case of a negative answer, they specified if they were living with spouse, children, family, or others.

SRH was measured by asking this question: "How would you say is your health: very good, good, fair, poor, or very poor?" For analytic purposes, SRH was categorized into three groups: "good/very good," "fair," and "poor/very poor." To measure "number of chronic conditions," participants reported if they ever were diagnosed by a physician for any of these eight medical conditions: hypertension, heart diseases, diabetes, cancer, chronic respiratory disease, stroke, arthritis, and osteoporosis. The total number of chronic diseases was used as a continuous variable in the analysis with a range of 0–7, and the participants were asked if they used a medication in the past 2 weeks. Visual acuity was measured at 2 m using the Early Treatment Diabetic Retinopathy Study (ETDRS) Tumbling E chart (13). Scores were converted to logMAR. Visual impairment was defined using the World Health Organization definition (presenting visual acuity worse than 6/18 in the better eye).

Physical frailty is defined as the presence of three or more of the following conditions: unintentional weight loss, weakness, self-reported exhaustion, slow walking speed, and low physical activity. The operationalization of these criteria used definitions similar to those used by Fried and colleagues (14). Details have been described elsewhere (15).

To assess participants' cognitive function, we used the Leganés cognitive test, a test originally developed for screening of dementia in low-educated populations (16). With a possible range between 0 and 32, a Leganés cognitive test score of 22 or lower is indicative of cognitive decline (16). The 20-item Center for Epidemiologic Studies Depression Scale (CES-D), a self-report tool to evaluate depressive symptoms over the preceding week (range of scores: 0–60), was used to measure depression (17). Similar to other studies (18), we defined clinically relevant depression as having a CES-D score of ≥16.

Fall was defined as "an unexpected event in which the participant comes to rest on the ground, floor, or a lower level" (19). The occurrence of falls was assessed retrospectively, and a recurrent faller was defined as any participant with at least two falls within the last year. We defined injurious falls if medical care was requires after the fall.

Physical performance was assessed by the Short Physical Performance Battery (SPPB) (20). The SPPB includes tests of walking speed, standing balance, and chair stand. Each SPPB component (gait, balance, and chair stand) is scored from 0 to 4, with a score of 0 representing inability to carry out the test and a score of 4 the best performance. For balance, the participants are asked to maintain their feet in side-by-side, semi-tandem, and tandem positions for 10 seconds each. For gait, a 4-m walk at the participants' usual speed was timed. For the chair stand test, participants were asked to stand up and sit down five times as quickly as possible. The summary performance score is the sum of component scores (range 0–12) with higher scores indicative of better lower body function. For analyses, we used the continuous SPPB score, a dichotomous indicator of low physical performance (SPPB < 8) (21), and individual scores of each component.

Other aspects of disability were also included in the analysis. "Mobility disability" was defined as the self-reported difficulty in

walking 400 m or climbing a flight of stairs without resting including need of walking use based on the Nagi questionnaire (22). Answers were summed, and participants were grouped into two categories: "no difficulties" or "any difficulty." Finally, "activities of daily living" disability was assessed by inquiring about difficulties in performing daily activities of toileting, bathing, dressing, getting out of bed, and walking across a small room (23).

Statistical Analysis

Characteristics of the cohort measured in 2014 in the total sample as well as by FOF status (in 2016) were summarized by descriptive statistics. We used bivariate logistic regression models to estimate risks of the occurrence of newly formed FOF in 2016 corresponding to baseline variables. Recursive partitioning with conditional inference tree (CTree) algorithm was performed to identify FOF risk subgroups (24). CTree partitions the observations by univariate splits in a recursive way and is an improvement of the traditional CaRT, which suffers from methodological issues such as "over-fitting," "selection bias towards covariates with many possible splits," and "lacking a statistical testing procedure."

CTree embeds recursive binary partitioning into a well-defined theory of permutation tests developed by Strasser and Weber (25), which is a bootstrapping nonparametric resampling method. CTree can be considered as base learners for random forest that provides an informative graphical display of results. For a set of covariates, CTree calculates p values using permutation tests for each variable and splits the data by the covariate with the smallest p value. For continuous partitioning variables, CTree selects an optimal cutoff point and splits subjects into two subgroups. With the goal of reaching an unbiased tree, the procedure repeats until a stopping criterion is satisfied. Stopping criteria may include predefined p values from multiple test procedures, minimum terminal nodes, or minimum sample size to be considered for splitting. We imposed two stopping criteria: (i) 5% level of significance and (ii) minimum sample size of 50 at terminal nodes.

After performing CTree, the random forest method with 2,000 iterations was used to verify the "importance" of risk factors initially identified by the CTree. Then, multiple logistic regression analyses were conducted to estimate the effects of all risk factors. To compare the effectiveness of CTree with multiple logistic regression methods, we calculated prediction accuracy, sensitivity, specificity, positive predictive value, and negative predictive value for both the CTree and the logistic regression models. Statistical software of SPSS (version 23.0; SPSS, Inc., Chicago, IL) and R (version 3.4.3) with the "party" package was used for the analysis.

Results

A total of 356 participants (24.8% of the total sample) reported FOF preceding the 2016 follow-up interview. Chi-square tests found significant differences between percentage of FOF across age groups (19.8% for age group of 64–69 vs. 31.3% for 70–75, $p < .0001$). FOF was more frequently in women (33.6% in women vs. 15.1% in men, $p < .0001$). Except "medication use," all variables (assessed in 2014) were significantly associated with the FOF measured in 2016 (Table 1). The stratified by site results of bivariate analyses are presented in Supplementary Table 2.

The classification tree for the 2-year follow-up is illustrated in Figure 1. CTree procedure identified 12 end nodes each with a different risk profile for developing FOF. Number of predictors in each node varied from a minimum of two (node 3) to a maximum of five (node 23). The first major split in the tree was related to "≤8" versus ">8" in the total SPPB scores. Eighty-two percent of the respondents who reported functional impairment (SPPB ≤ 8) and mobility disability (by Nagi questionnaire) reported FOF in the 2 years to follow-up (node 3). Those with functional impairment but no self-report of mobility disability were split further into two main high-risk groups: 65% of women in the age group of 70–75 years old developed FOF (node 10), whereas only 37% of men (any age) with poor SRH developed FOF (node 6).

CTree also identified three other high-risk end nodes for respondents who did not report functional impairment (SPPB > 8). Within this high functioning group, female individuals with equal or less than 5 years of schooling formed end node 14 with a 39.8% risk of developing FOF in the 2 years of follow-up, whereas in men, with the same characteristics, the risk was almost half at 20.3% (node 13). Respondents with more than 5 years of schooling were further divided according to their SRH status and formed two additional branches. A high-risk group was formed when the "poor SRH" branch was further split by a different cutoff point of the SPPB total score (<10 vs. >10). Individuals with low SPPB score in this branch showed 31.5% risk for development of FOF (node 17).

The most favorable result belonged to node 20 with only 4% at risk of FOF. This group included participants with no functional limitation, more than 5 years of schooling, good SRH, and living alone or with their spouse.

In summary, between 23.2% and 82.3% of the risk of developing FOF in 2 years of follow-up were explained by only five variables: age, sex, SRH, functional impairment measured by SPPB, and mobility disability. For people with no functional impairment or mobility disability, levels of education, sex, and SRH were important predictors of FOF in the future.

As shown in Supplementary Figures 3 and 4, when the regression CTree is performed stratified by sex, in men, the first split is functional impairment, followed by schooling and impairment in two or more task of activities of daily living predicting FOF, whereas in women, functional impairment measured by SPPB and SRH are more important factors in relation to FOF.

Multiple logistic regression models identified age, sex, education, mobility disability, and SPPB total score as independent contributors to the development of FOF with the largest odds ratio for mobility disability (odds ratio: 6.28, 95% confidence interval: 2.71–14.57; Figure 2). CTree correctly classified 1,032 of 1,078 older people without FOF (specificity: 95.7%, negative predictive value: 81.2%) and 117 of 356 of those with FOF (sensitivity: 32.9%, positive predictive value: 71.8%). Specificity of logistic models was lower (74.1%) by identifying 270 people without FOF (negative predictive value: 91.2%), but sensitivity was higher (78.4%) by identification of 279 fallers (positive predictive value: 50%). Final classification accuracies were 80.1% for CTree and 75.2% for multiple logistic regression models.

Discussion

To our best knowledge, this is the first study using tree-structured recursive partitioning with a conditional inference tree (CTree) algorithm for the development of a classification tree to predict FOF in community-dwelling older adults. By clear identification of specific combinations of predictors, the results of this 2-year prospective study showed a classification tree with 12 end groups, each with a different risk of developing FOF. The end groups were identified with

Table 1. Sample Characteristics and Comparison of Fear of Falling (n = 1,434)

	Total (n, %)	FOF (n, %)	No FOF (n, %)	Crude Logistic Model	
	N = 1,434	356 (24.8%)	1,078 (75.2%)	OR (95% CI)	p Value
Age group					
64–69	808 (56.3)	160 (19.8)	648 (80.2)		
70–75	626 (43.7)	196 (31.3)	430 (68.7)	1.85 (1.45, 2.35)	<.0001
Sex					
Male	681 (47.5)	103 (15.1)	578 (84.9)		
Female	753 (52.5)	253 (33.6)	500 (66.4)	2.84 (2.19, 3.68)	<.0001
Years of schooling					
Mean (*SD*)	10.2 (5.7)	7.5 (5.0)	11.1 (5.7)	0.89 (0.87, 0.91)	<.0001
Living arrangements					
With spouse	580 (40.4)	88 (15.2)	492 (84.8)		
With other	597 (41.6)	211 (35.3)	386 (64.7)	3.06 (2.30, 4.05)	<.0001
Alone	257 (17.9)	57 (22.2)	200 (77.8)	1.59 (1.10, 2.31)	.0140
Self-rated health					
Excellent/very good	854 (59.6)	127 (14.9)	727 (85.1)		
Fair	521 (36.3)	194 (37.2)	327 (62.8)	3.40 (2.62, 4.40)	<.0001
Poor/very poor	59 (4.1)	35 (59.3)	24 (40.7)	8.35 (4.80, 14.5)	<.0001
Chronic diseases					
Mean (*SD*)	2.0 (1.3)	2.4 (1.4)	1.9 (1.3)	1.38 (1.26, 1.52)	<.0001
Use of any medication					
No	156 (10.9)	30 (19.2)	126 (80.8)		
Yes	1,278 (89.1)	326 (25.5)	952 (74.5)	1.44 (0.95, 2.18)	.0880
Visual impairment					
No	1,266 (88.3)	289 (22.8%)	977 (77.2%)		
Yes	168 (11.7)	67 (39.9%)	101 (60.1%)	2.24 (1.60, 3.14)	<.0001
Frailty					
Vigorous	686 (47.8)	104 (15.2)	582 (84.8)		
Prefrail	655 (45.7)	188 (28.7)	467 (71.3)	2.25 (1.72, 2.95)	<.0001
Frail	93 (6.5)	64 (68.8)	29 (31.2)	12.4 (7.6, 20.1)	<.0001
CES-D					
Not depressed	1,200 (83.7)	248 (20.7)	952 (79.3)		
Depressed	234 (16.3)	108 (46.2)	126 (53.8)	3.29 (2.46, 4.41)	<.0001
Dementia screening					
Negative	1,407 (98.1)	342 (24.3)	1,065 (75.7)		
Positive	27 (1.9)	14 (51.9)	13 (48.1)	3.35 (1.56, 7.20)	.0019
Falls last year					
0 fall	1,058 (73.8)	237 (22.4)	821 (77.6)		
1 fall	237 (16.5)	63 (26.6)	174 (73.4)	1.25 (0.91, 1.73)	.1684
2 or more falls	139 (9.7)	56 (40.3)	83 (59.7)	2.34 (1.62, 3.38)	<.0001
Injurious fall					
Noninjurious fall	288 (20.1)	74 (25.7)	214 (74.3)		
Injurious fall	88 (6.1)	45 (51.1)	43 (48.9)	3.03 (1.85, 4.96)	<.0001
No fall	1,058 (73.8)	237 (22.4)	821 (77.6)	0.83 (0.62, 1.13)	.2401
Total SPPB score					
Mean (*SD*)	9.5 (2.0)	8.2 (2.1)	10.0 (1.7)	0.61 (0.57, 0.66)	<.0001
SPPB balance					
0	6 (0.4)	4 (66.7)	2 (33.3)		
1	22 (1.5)	11 (50.0)	11 (50.0)	0.50 (0.08, 3.32)	.4727
2	66 (4.6)	39 (59.1)	27 (40.9)	0.72 (0.12, 4.23)	.7181
3	429 (29.9)	165 (38.5)	264 (61.5)	0.31 (0.06, 1.73)	.1821
4	911 (63.5)	137 (15.0)	774 (85.0)	0.09 (0.02, 0.49)	.0054
SPPB gait speed					
0	8 (0.6)	4 (50.0)	4 (50.0)		
1	37 (2.6)	23 (62.2)	14 (37.8)	1.64 (0.35, 7.64)	.5267
2	133 (9.3)	67 (50.4)	66 (49.6)	1.02 (0.24, 4.23)	.9835
3	365 (25.5)	137 (37.5)	228 (62.5)	0.60 (0.15, 2.44)	.4764
4	891 (62.1)	125 (14.0)	766 (86.0)	0.16 (0.04, 0.66)	.0111
SPPB chair stand					
0	39 (2.7)	23 (59.0)	16 (41.0)		
1	266 (18.5)	117 (44.0)	149 (56.0)	0.55 (0.28, 1.08)	.0825
2	360 (25.1)	96 (26.7)	264 (73.3)	0.25 (0.13, 0.50)	<.0001
3	439 (30.6)	87 (19.8)	352 (80.2)	0.17 (0.09, 0.34)	<.0001
4	330 (23.0)	33 (10.0)	297 (90.0)	0.08 (0.04, 0.16)	<.0001

Table 1. Continued

	Total (*n*, %)	FOF (*n*, %)	No FOF (*n*, %)	Crude Logistic Model	
	N = 1,434	356 (24.8%)	1,078 (75.2%)	OR (95% CI)	*p* Value
Walking aid use					
No	1,359 (94.8)	308 (22.7)	1,051 (77.3)		
Yes	75 (5.2)	48 (64.0)	27 (36.0)	6.07 (3.72, 9.89)	<.0001
Mobility disability					
No	1,358 (94.7)	297 (21.9)	1,061 (78.1)		
Yes	76 (5.3)	59 (77.6)	17 (22.4)	12.4 (7.12, 21.6)	<.0001
ADL					
0	37 (2.6)	24 (64.9)	13 (35.1)		
1	112 (7.8)	53 (47.3)	59 (52.7)	0.49 (0.23, 1.05)	.0668
2	164 (11.4)	66 (40.2)	98 (59.8)	0.36 (0.17, 0.77)	.0079
3	1,069 (74.5)	188 (17.6)	881 (82.4)	0.12 (0.06, 0.23)	<.0001
4	52 (3.6)	25 (48.1)	27 (51.9)	0.50 (0.21, 1.19)	.1187

Notes: ADL = Activities of Daily Living; CES-D = Center for Epidemiologic Studies Depression Scale; CI = confidence interval; FOF = Fear of Falling; SPPB = Short Physical Performance Battery; OR = odds ratio. Numbers inside parentheses represent row percentages and are rounded to the nearest first decimal.

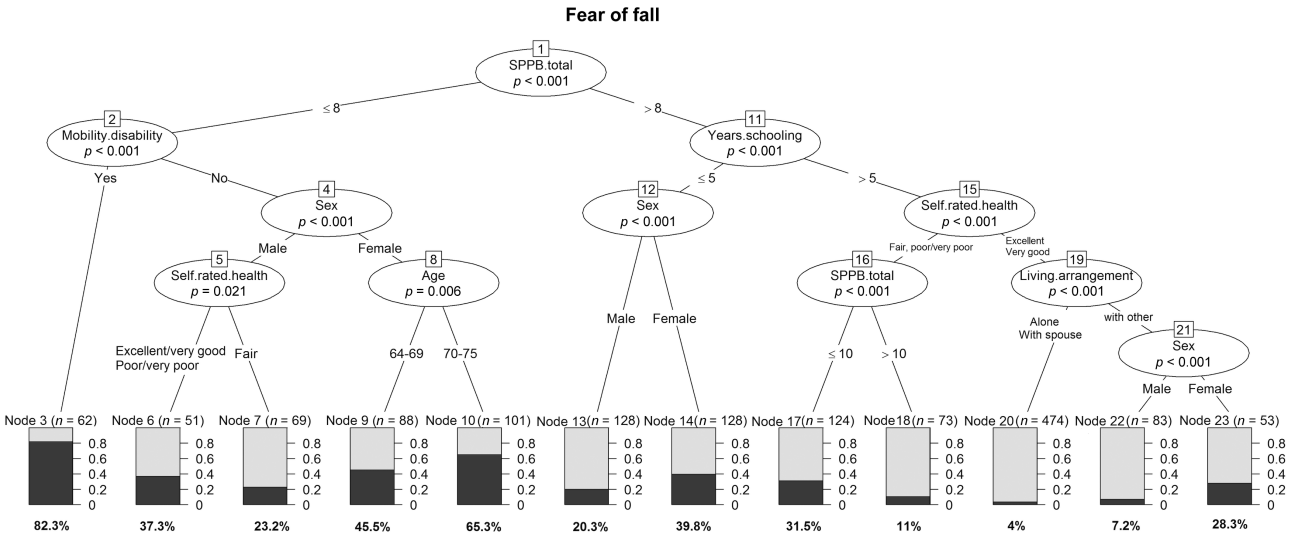

Figure 1. The classification tree for predicting the risk of fear of falling in community-dwelling older persons at 2-y follow-up. SPPB = Short Physical Performance Battery.

a minimum of two and a maximum of five predictors. Two variables directly related to mobility (SPPB and self-report of mobility disability) explained up to 82% of the probability of occurrence of FOF in 2 years of follow-up. Age, sex, and SRH were additional identified risk factors for the development of FOF in the mobility impairment group. In respondents with no functional impairment or mobility disability, levels of education, sex, and SRH were important predictors of FOF.

Our study confirmed the importance of previously documented (3,5,7) risk factors of FOF in older people: old age, female sex, low levels of education, living alone, poor SRH, and impaired physical functioning (either self-reported or performance-based) and in agreement with a recent systematic review that reported female gender, impaired physical function (either questionnaire- or performance-based and mostly involving mobility tasks), and use of a walking aid are risk factors robustly associated with FOF (7).

Identification of mobility-related factors in splitting participants into high-risk groups is noteworthy. A consistent finding with other studies that reported impaired physical functioning—measured by walking disability (26–29), mobility disability (27,28), and instrumental activity of daily living (27,28) and activity of daily living difficulties (27,30)—as the most robust risk factors for FOF (7). Together with these cross-sectional and longitudinal analyses, our findings support the hypothesis that impaired physical functioning may precede the development of FOF. In other words, FOF may be the consequence of an already existing impairment in physical functioning. Concerns about the possibility of falling can lead to self-imposed restriction of activities and then further decline in mobility. The ensuing vicious circle may cause a real decline in physical capacity and therefore increased fall risks (31). In other analyses using the IMIAS sample, we provided empirical evidence for both cross-sectional (32) and longitudinal (33) associations between FOF and risk of mobility disability and poor physical performance. In the longitudinal analysis, after adjustment for age, sex, socioeconomic status, and pertinent health covariates, a one-point increase in FES-I scores was associated with a 4% increase in the risk of reporting incident mobility disability and a 3% increase in the risk of developing poor physical performance at 2-year follow-up (33).

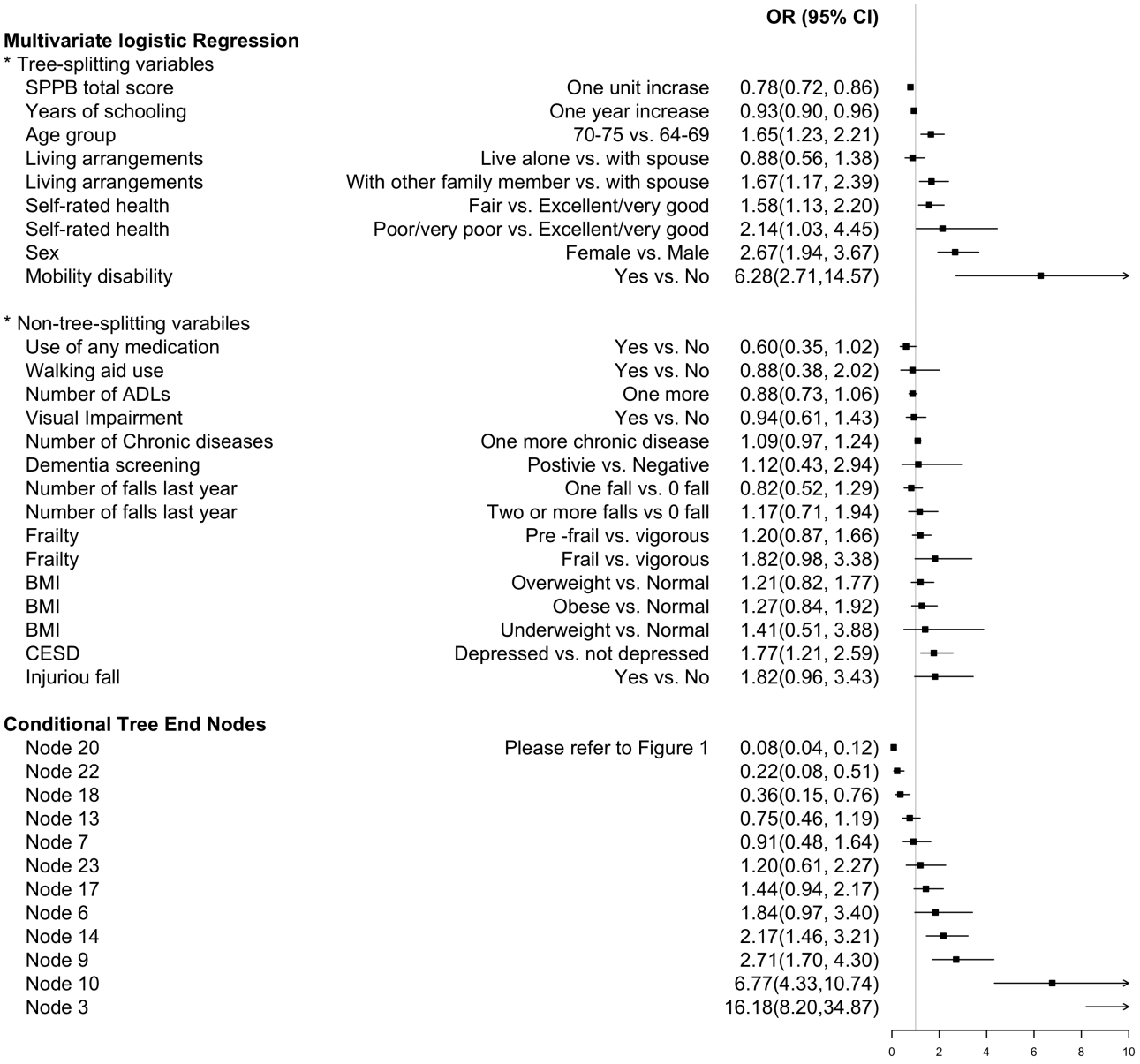

Figure 2. Odds ratio (OR) and 95% confidence interval (CI) for the incidence of fear of falling according to the single risk factor (n = 1,434). ADL = Activities of Daily Living; BMI = body mass index; CES-D = Center for Epidemiologic Studies Depression Scale; SPPB = Short Physical Performance Battery.

Regression tree identified other factors that may also explain FOF in older people with impaired physical functioning, namely female sex and older age. According to the model older women with impaired physical function were more likely to develop FOF. This group, 65% of the sample, represents a population in which a dedicated health care FOF prevention is a priority. In people without physical performance impairment, female sex was also an important factor, but lower educational level substituted older age as the second important factor for developing FOF. Low educational level and low socioeconomic status have been reported previously as important prognosis factors associated with FOF (28,34,35). Three pathways through which socioeconomic status affects health have been postulated, including its influence on health care access, environmental exposures, and health behaviors (36). Another important factor identified in the regression tree was SRH. We previously found that older people with activity restriction due to FOF reported higher prevalence of poor self-perceived health than did those with no FOF (28), and our finding was consistent with precedents (28,30,37,38).

Despite the observed bivariate associations between history of falling and recurrent falls with FOF, both multiple logistic regression and classification tree models failed to detect such associations. This highlights the importance of FOF as a health issue threatening the autonomy of older people independently from actual fall events (3). Factors such as history of falls, polypharmacy, use of psychotropic drugs, depression, and anxiety show unclear associations with FOF in our analysis. They also reported to be less robustly associated with FOF as per evidence synthesis of a systematic review (7). One potential explanation is that some factors as falls, depression, and anxiety are highly correlated or are even part of the outcome (FOF) itself.

These findings are particularly useful in designing targeted FOF prevention programs for specific subgroups with mobility limitations (39). Because self-report of disability mobility and objective measure of physical function (SPPB) together were able to identify at least 82.3% of people at the risk of FOF, we suggest including an measurement of physical functioning in the assessment of older adults in primary care settings in different social and cultural contexts to identify older adults with risk of FOF. These measurements should include the SPPB as an objective measure and the Nagi physical limitation questionnaire as a subjective measure. Regarding the successful prevention of FOF in the community, the present study's findings underscore the importance of identifying older adults with impaired physical functioning (self-report and/or performance-based), and implementation of targeted approaches in this subgroup. Furthermore, people with physical impairment and disability mobility should be encouraged to exercise regularly. Due to fall concerns, physical activity decreases as FOF increases (40), and a rehabilitation intervention program is needed to improve performance of daily activities.

This study has potential clinical and public health practical implications. Several identified predictors of FOF are at least partially modifiable. Examples include impaired physical performance and mobility, poor subjective health, low education, and living arrangement. However, the multifactorial nature of FOF warrants adoption of multicomponent interventions. The optimum type of intervention and the best choice of individual components are still a subject of debate (7), but strategies for physical training, cognitive stimulation, and efforts to enhance autonomy in community-dwelling older people can potentially be beneficial and able to break the cascade of FOF and subsequent falling events.

The main strength of this study is the adopted tree-based analysis methodology that offers several advantages over traditional logistic regression models. First, regression trees do not require any prior distributional assumption and information about relationships between variables. Second, findings of regression trees are useful for stratification of risks and direct determination of the prognosis of developing FOF in specific groups. Third, by identifying only a few measurable predictors, CTree allows the construction of simple high-risk FOF profiles. The latter has practical applications in primary care settings and public health. The other strength of this study relates to robustness of our analysis. Multiple logistic regression analyses resulted in similar results and confirmed the reliability of CTree results. In addition to methodological advantages, use of population-based samples from different socioeconomic and cultural backgrounds—suggesting that the identified risk profiles can be implementable in diverse older adult populations—and high retention rates are other strengths of this study.

The main limitation of this study is the inclusion of only community-dwelling older adults in a short age range between 65 and 74 years. Thus, the finding might not be generalizable to those populations who possibly suffer more from FOF such as people older than 75 years or frailer, institutionalized seniors. Second, until our findings are reproduced in independent populations, our analysis remains exploratory.

Conclusion

Using CaRT techniques, we identified specific combinations of risk factors for FOF in five international samples of older people. The combination of risk factors most associated with developing FOF 2 years later was impaired physical functioning (measured by SPPB) with mobility disability (ascertained by Nagi questionnaire). In respondents with intact physical functioning, low education level, gender sex, and poor SHR were major predictors of FOF. Our findings highlight the importance of rehabilitation and physical training as pivotal interventions for any successful therapeutic or prevention approach to FOF. Understanding factors associated with FOF will help clinicians to identify those most at risk. Such older people benefit from prevention interventions that reduce both FOF and possibly risk of future falls.

Supplementary Material

Supplementary data is available at *The Journals of Gerontology, Series A: Biological Sciences and Medical Sciences* online.

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Conflict of Interest

None reported.

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