Published in final edited form as:

Am J Phys Med Rehabil. 2018 June ; 97(6): 426–432. doi:10.1097/PHM.0000000000000889.

Inability to Perform the Repeated Chair Stand Task Predicts Fall-related Injury in Older Primary Care Patients

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Abstract

Objective—To examine whether the chair stand component of the Short Physical Performance Battery (SPPB) predicts fall-related injury among older adult primary care patients.

Design—2-year longitudinal cohort study of 430 Boston-area primary care patients aged 65 years screened to be at risk for mobility decline. The three components of the SPPB (balance time, gait speed, and chair stand time) were measured at baseline. Participants reported incidence of fall-related injuries quarterly for two years. Complementary log-log discrete time hazard models were constructed to examine the hazard of fall-related injury across SPPB scores, adjusting for age, gender, race, Digit Symbol Substitution Test score, and fall history.

Results—Participants were 68% female and 83% white, with a mean age of 76.6 (SD=7.0). A total of 137 (32%) reported a fall-related injury during the follow-up period. Overall, inability to perform the chair stand task was a significant predictor of fall-related injury (HR [hazard ratio]=2.11, 95% CI=1.23–3.62, p=0.01). Total SPPB score, gait component score, and balance component score were not predictive of fall-related injury.

Conclusion—Inability to perform the repeated chair stand task was associated with increased hazard of an injurious fall over 2 years among a cohort of older adult primary care patients.

Keywords

falls; injury; aged; risk assessment

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Author Disclosures: There are no competing interests or financial benefits to the authors to disclose

The main results of this study have been presented as a poster presentation at the 2017 American Congress of Rehabilitation Medicine conference. This study has not been previously submitted to any journal.

Introduction

Approximately 40% of community-dwelling Americans age 65 years experience at least one fall per year.¹ In this age group, falls are associated with an increased risk of functional decline, and are a strong predictor of placement in nursing homes and skilled nursing facilities. They can lead to serious injuries, including fractures, joint dislocation, and severe head injury, with potential life-threatening complications.² In fact, one-year survival among those admitted to a hospital for a fall-related injury is estimated at only 50%.¹ Moreover, rates of severe fall-related injury may be on the rise. A recent Center for Disease Control and Prevention report found that the rate of fall-related traumatic brain injury in older adults increased between 2007 and 2013.³ For these reasons, easy-to-administer fall injury screening tools are urgently needed.

In addition to a focused history and physical examination, both the American Geriatrics Society and Center for Disease Control and Prevention have highlighted the utility of standardized physical performance measures to stratify future fall risk.⁴ A number of standardized assessments have been developed that evaluate gait, strength, coordination, and balance. While a variety of physical performance tests predict incidence of future falls,^{5,6} it is unknown whether these physical performance tests also predict fall-related injury, a potentially more clinically relevant outcome.

The Short Physical Performance Battery (SPPB)⁷ is a 3-part physical performance assessment that tests repeated chair stand ability, gait speed, and balance. The SPPB is a valid, reliable predictor of short-term mortality⁷ and future disability.⁸ More recently, researchers found that the component score of the repeated chair stand task, but not total SPPB score, was predictive of future fall-related injury in MOBILIZE Boston, a population-based cohort of 765 community-dwelling adults age 70 years.⁹ A simple physical performance test, such as the repeated chair stand, could be an extremely useful screening test among primary care patients with known mobility limitations if able to predict those who are at greatest risk for future fall-related injury. There are a number of reasons why physical performance tests that are predictive among the general community-dwelling population may have a different association with fall injury among primary care patients at greater risk for decline in mobility skills. For example, in primary care patients with self-reported mobility limitations and higher frequency of prior falls, more patients may have previously undergone rehabilitative therapies, impacting both their performance of different physical tasks and likelihood for fall injury. Likewise, primary care patients with mobility problems may manifest differences in self-efficacy similarly impacting the performance of mobility tasks and potential risk for injury. Such factors make it necessary to show that the predictive ability of physical performance tools, such as the SPPB and its components, are replicable in the relevant population before adopting it as a screening tool.

The Boston Rehabilitative Impairment Study of the Elderly (Boston RISE) is a longitudinal cohort study of 430 primary care patients derived from 12 primary care clinics in the Greater Boston area who were identified as being at risk for developing future disability on the basis of manifesting mobility limitations or task modification with mobility skills.^{10,11} The principal aim of this analysis was to assess the replicability of the MOBILIZE Boston

findings in this separate cohort by examining whether the SPPB or its components were predictive of fall-related injury over 2 years of follow-up. It was hypothesized that as in MOBILIZE Boston, the chair stand component score, but not total SPPB score, gait component score, or balance component score, would predict fall-related injury.

Methods

Boston RISE

Inclusion criteria included ability to communicate in English and self-reported difficulty walking six blocks or up one flight of stairs. Participants were excluded from the study for the following reasons: terminal illness, major surgery or myocardial infarction within the past six months, planned surgery or move from Boston within 2 years, Mini-Mental State Examination (MMSE) score <18 (corresponding to moderate to severe cognitive impairment),¹² and SPPB⁷ score <4 (on a scale of 0 to 12, with lower score indicating greater physical impairment). The study sample size (n=430) was determined to be sufficient for this secondary analysis based on previously established criteria recommending a sample of at least 10 participants who experienced the event of interest (in this case, an injurious fall) for each model variable in proportional hazards models.¹³ All study procedures were approved by the Spaulding Rehabilitation Hospital's Institution Review Board, and written informed consent was obtained from all participants at the baseline study assessment. This study conforms to the STROBE guidelines and reports the required information accordingly (Supplementary Checklist).

Baseline Characteristics

A nurse practitioner and research assistant conducted an initial baseline assessment of each participant, which included a physical exam, neuropsychological testing, and collection of data on demographics, medical history, and medication use. Baseline characteristics hypothesized to impact risk of fall-related injury were included in this analysis, including age, gender, BMI, race, education, fall history, use of psychotropic medication, depressive symptoms, peripheral sensory loss, visual impairment, balance confidence, and cognitive impairment.^{1,4,14} Any medication classified under the Iowa Drug Information Service (IDIS) class "psychotherapeutic agents" or "anxiolytics" was considered a psychotropic medication. A participant was considered to have depressive symptoms if he or she scored greater than 4 on the PHQ-9 questionnaire.¹⁵ Sensory loss was defined as feeling less than 3 of 4 applications of a 4.17 and 5.07 monofilament to the dorsum of either big toe.¹⁶ Visual impairment was defined as inability to correctly read the 20/50 line of a Snellen eye chart from 20 feet (with corrective vision, if typically used for distances). Balance confidence was measured using the Activities-Specific Balance Confidence (ABC) Scale.¹⁷ Cognition was assessed using the Digit Symbol Substitution Test (DSST)¹⁸ and the MMSE.¹² All baseline measures are reliable and valid among older adults.¹⁰ Two weeks after the initial baseline visit, a research assistant conducted a second baseline visit, which included physical performance testing and completion of questionnaires on functional ability, prior falls, physical activity, and rehabilitative care as previously detailed.¹⁰ Of the measures taken during the second baseline visit, this analysis uses only the SPPB (see below) and participants' report of falls within the last year.

The Short Physical Performance Battery (SPPB)

At baseline, participants completed the SPPB, a validated, reliable evaluation of lower extremity function.^{7,8} The SPPB has three timed components: 1) a 4-meter usual-pace walk 2) three balance stances and 3) five repeated chair stands (without using one's arms). Component times are converted to component scores ranging from 0–4, with higher score corresponding to greater functional status. A score of 0 is given if the participant deems the task too unsafe to attempt or attempts the task but is unable to complete it. In this cohort, all participants were able to perform the gait task, so no one received a gait component score of 0. The three component scores are summed to yield a total score ranging from 0–12. Of note, the raw repeated chair stand time and 4-meter usual-pace walk can also be examined as continuous variables in seconds, but the decision was made to exclusively examine these categorically as they are classified by the SPPB. This was done both for scientific reasons, for ease of comparison to the findings of MOBILIZE Boston, and for clinical reasons, as providers can more easily risk-stratify patients using these established cut-points that are components of SPPB testing.

Falls Assessments

At baseline, participants were asked, “How many times have you fallen in the past year?” Over the two year follow-up period, every three months participants were contacted by telephone and asked: 1) “Have you fallen to the ground in the past 3 months?” 2) “If so, how many times?” 3) “As a result of your worst fall, were you injured?” and 4) “Did you stay overnight in the hospital because of a fall?” If the participant could not be reached on the first call attempt, additional attempts were made. A fall was defined as an unexpected event in which the participant came to rest on the ground, floor, or lower level.¹⁹ Participants were allowed to use their own definition of injury.

Statistical Analysis

Associations between baseline characteristics and fall-related injury over the two-year period were examined using t-tests for normally distributed continuous variables, Mann-Whitney U tests for non-normally distributed continuous variables, and χ^2 tests for categorical variables (Fischer's exact test was used for cells with expected sizes less than 5).

Complementary log-log discrete time hazard models were then built to model time to first fall-related injury. A manual backwards elimination method was used to construct multivariable models (with baseline characteristics + the performance-based measure of interest as predictors of time to first fall-related injury). Removal of variables was done in an iterative process, starting with the highest non-significant p-value. Baseline characteristics that were statistically significant ($p < 0.05$) were retained in the final models. Four models were constructed, with the performance-based measure as follows: model 1: total SPPB score, model 2: gait speed component score, model 3: balance component score, model 4: chair stand component score. In model 1, total SPPB score was grouped into low functioning (4–6 points), middle functioning (7–8 points), and high functioning (9–12 points) as was previously done by Ward et al. Non-significant baseline characteristics were then individually reintroduced into the final models to check if any altered the estimates of the hazards associated with the performance-based measure of interest (SPPB or SPPB

component score) by 20%. All models included age and sex as adjustment variables regardless of significance. The significance of interaction terms between model variables and follow-up time was tested in each of these models in order to test the proportional hazards assumption. Hazard ratios (HR) and 95% confidence intervals (CI) were used to estimate risk factors of injurious falls. An alpha level of 0.05 was used to determine statistical significance. Goodness-of-fit of all models was assessed with the Akaike information criteria (AIC) and c-statistic (AUC). All statistical analysis was performed with SAS Studio version 3.6 (SAS Institute, Inc., Cary, NC).

Results

Participants were 68% female, 83% white, and had a mean age of 76.6 (SD=7.0). Over the 2-year follow-up period, 137 participants (31.8%) reported at least one fall-related injury. Of the first reported fall-related injuries used in the modeling, 20 (14.6%) resulted in an overnight hospital stay (bone fracture=12, head laceration=2, contusion=5, specific injury not reported=1). Participants who reported a fall-related injury during the follow-up period were significantly more likely to be white ($p=0.01$) and to have experienced a fall during the year prior to the study baseline ($p=0.005$). Other baseline characteristics did not significantly differ between those with and without fall-related injuries (Table 1). Over the two-year follow-up period, a total of 17 participants (4.0%) withdrew from the study and 7 participants (1.6%) died before reporting any fall-related injury (these deaths were confirmed by next of kin or obituaries). The number of remaining participants at each follow-up who were unable to be reached via phone to ask about fall-related injury during the past three months ranged from 11 to 48 (Supplementary Table 1). Participants who missed at least one follow-up call for unknown reasons (not known to be deceased or have left the study) did not significantly differ from the rest of participants with respect to gender ($\chi^2[\text{df}=1 \text{ N}=430]=0.20$, $p=0.65$), age ($t[\text{df}=428]=1.05$, $p=0.30$), or prevalence of fall history ($\chi^2[\text{df}=1 \text{ N}=428]=2.75$, $p=0.10$), but were significantly less likely to be white (74% white vs. 87% white among rest of participants, $\chi^2[\text{df}=1 \text{ N}=430]=10.53$, $p=0.001$).

All constructed models met the proportional hazards assumption. Six participants were excluded from the models due to missing data (two participants with unknown fall history, one participant with missing baseline DSST score, one participant who withdrew from the study and two participants who died before the first quarter phone call). In Model 1 total SPPB score was not a significant predictor ($p=0.77$) and the hazard of fall-injury did not significantly differ between those who scored 4–6, 7–8, or 9–12 points (Table 2). Likewise, in Model 2, gait component score was not a significant predictor ($p=0.94$), and the hazard of fall-related injury did not significantly differ across gait component scores (Table 3). In the model including the balance task component score (Model 3), balance score was not a significant predictor ($p=0.32$), though a significant difference in the hazard of fall-related injury was observed between a score of 0 (unable to perform task) and a score of 1 (HR=3.81, 95% CI=1.09–13.35). In the model including the chair stand component score (Model 4), the chair stand score approached significance ($p=0.08$) as a predictor. A chair stand score of 0 was associated with a significantly increased hazard of fall-related injury compared to scores of 1, 2, or 3 (0 vs. 1: HR=2.40, 95% CI=1.25–4.60, 0 vs. 2: HR=2.34, 95% CI=1.27–4.31, 0 vs. 3: HR=2.00, 95% CI=1.09–3.66), but not compared to a score of 4

(0 vs. 4: HR=1.70, 95% CI=0.89–3.22). Across all of these models race, fall history, and DSST score were retained as significant baseline characteristics, with white race, fall history, and lower DSST scores associated with a significantly increased hazard of fall-related injury. When non-significant baseline characteristics were individually reintroduced into the final models, none altered the estimates of the hazards associated with the performance-based measure of interest (SPPB or SPPB component score) by 20%, so none were included in the final models. Out of the four final models, the c-statistic was largest and AIC was smallest in Model 4, the chair stand model (c=0.646, AIC=1056.5), indicating the best model fit.

Given the findings observed in Model 4, an additional model that included chair stand ability as a binary predictor was constructed using the same method as above (Model 5, Table 4). This model was also constructed to identify if a single cut-point could be used as a clinical predictor to differentiate low-risk vs. high-risk individuals. In this model, inability to perform the chair stand task was a significant predictor (p=0.01), associated with a significantly increased hazard of fall-related injury (HR=2.11, 95% CI=1.23–3.62). Figure 1 depicts this graphically, showing the modeled cumulative incidence of fall-related injury in those unable to perform the chair stand task, with those able to perform the task as the reference (holding all other model covariates constant as the typical study participant: female, white race, age of 76.6, DSST score of 36.3, no prior fall history). This plot shows the survival model associated with the complementary log-log discrete time hazard model, which follows the form $S(t, \mathbf{x}) = S_0(t)^{\exp\{\mathbf{b} \cdot \mathbf{x}\}}$. The term $S(t, \mathbf{x})$, the probability that an individual with model covariates $\mathbf{x}$ will survive to time t , is equal to the baseline survival function $S_0(t)$ at that time raised to the power of $\exp\{\mathbf{b} \cdot \mathbf{x}\}$ (the relative risk associated with covariates x_1, x_2, x_3 , etc., where b_1, b_2, b_3 , etc. are maximum likelihood estimates determined by the data). Figure 1 shows a predicted a 2-year incidence of fall-related injury of 38% in those able to perform the repeated chair stand vs. 63% in those unable to perform the repeated chair stand. Lastly, a similar model was constructed with ability to achieve a full score (4 points) on the chair stand task as a binary predictor. In this model, a chair stand score of 4 was not associated with a statistically different hazard than scoring 0–3 points (HR=1.21, 95% CI=0.78–1.86, p=0.39).

Discussion

In this cohort, inability to perform the repeated chair stand task was associated with a significantly increased hazard of fall-related injury over the two-year study period. This increased hazard amounts to a clinically relevant 66% increase in incidence of injurious falls over a two-year period (Figure 1). The repeated chair stand is a complex task. Many neuromuscular factors, including reaction time, strength across the knee and ankle, balance, tactile sensitivity and proprioception, have been found to predict chair stand performance.²⁰ The results of this study suggest that inability to perform the chair stand task indicates a threshold of impairment across such neuromuscular factors that results in an increased risk of fall-related injury. Prior studies have found an association between this task and falls.^{21,22} While some studies have investigated whether this task predicts fall-related injury among community-dwelling older adults, this is the first study to examine the observed relationship

between chair stand performance and subsequent fall-related injury within a clinical context, among a cohort of primary care patients at risk for mobility decline.

Interestingly, inability to perform the task was associated with a significant increase in hazard (vs. able to perform the task), but in pairwise comparisons between scores, a more nuanced relationship existed. A score of 0 was associated with a significantly increased hazard as compared to scores of 1, 2, and 3, but not as compared to the best performance score of 4. Likewise, in MOBILIZE Boston, a nonlinear relationship was seen between chair stand score and hazard of injurious fall, with the hazard associated with a score of 4 being greater, and closer to the increased hazard associated with a score 1, than the hazards associated with intermediate scores of 2 or 3. A chair stand score of 4 in a mobility-limited individual could be a warning sign that the individual fails to make the appropriate task modifications, like intentionally slowing down when performing difficult motor tasks. These individuals may engage in other high-risk behaviors in their daily lives such as walking on slippery surfaces, rapidly ascending or descending stairs, etc., putting them at higher risk for fall-related injury. Alternatively, it may simply be that there was not sufficient power to detect the difference in hazards associated with scores of 0 vs. 4 due to the fact that these were the two score groups with the fewest participants (n=35 and n=74, respectively, vs. n=93 with a score of 1, n=116 with a score of 2, and n=112 with a score of 3).

While both the results from Boston RISE and MOBILIZE Boston suggest a relationship between the repeated chair stand task and injurious falls, the specific findings differ. In the MOBILIZE cohort, a chair stand score of 1 was associated with an increased hazard of fall-related injury as compared to scores of 2–4. A score of 0 was not associated with an increased hazard compared to other scores, as was found in the Boston RISE cohort. This difference in findings may have resulted from the differences between study participants. While MOBILIZE Boston participants were community-dwelling older adults, Boston RISE participants were primary care patients screened to be at risk for mobility decline (who self-reported difficulty walking six blocks or up one flight of stairs). Therefore Boston RISE participants likely had unique factors like fear of falling, prior history of rehabilitative therapy, etc. that altered their chair stand performance. Another difference between Boston RISE and MOBILIZE Boston was the collection method of fall injury data. In MOBILIZE Boston participants recorded incidence of falls on daily falls calendars that were turned in monthly. If a fall was recorded in a given month, the participant was called and asked if there was an associated injury. In Boston RISE incidence of fall-related injuries was ascertained through quarterly phone calls. This may have resulted in underreporting of injurious falls and could also have contributed to the difference in findings between this study and MOBILIZE Boston. An underreporting of events in this study would decrease event count and have the expected effect of biasing hazard ratios towards the null.

In agreement with the MOBILIZE Boston analysis, these findings support the clinical utility of the repeated chair stand task over the other SPPB subtasks as a screening tool for injurious falls in older adults. The difference in scores associated with injurious falls in MOBILIZE Boston vs. Boston RISE suggest that different chair stand score cut-offs are required to predict negative outcomes, such as injurious falls, among different patients populations. The results of the Boston RISE cohort suggest that simply screening patients

for the inability to perform the repeated chair stand task, rather than stratifying patients by chair stand time, may yield the most data with respect to risk of injurious falls among patients with self-reported mobility limitations.

Similar to the findings of Ward et al.,⁹ Welmer et al.²³ recently found that longer repeated chair stand times were associated with injurious falls among in their Swedish population-based study. In their study, each standard deviation longer chair stand time was associated with a significant decrease in risk of injurious falls. This contrasts to the findings within the present cohort, where ability to complete the task, but not differences in time among those who could complete the task, stratified hazard of injurious fall. This difference in findings between studies could again be explained by the fact that multiple factors such as prior rehabilitative therapies, fear of falling, and knowledge of mobility adaptations differ between community dwelling individuals and the at-risk population of the present study. These different factors could alter the predictive nature of chair stand performance. The discrepancy in findings again highlights the importance of testing such a screening test among different populations of interest and the potential need to refine score cut-offs to best predict outcomes, such as injurious falls. On the other hand, Zhang et al. found that the repeated chair stand task was not predictive of fall-related fractures.²⁴ This was likely due to too small a sample size for such a narrow definition of injury, given that only 10 fall-related fractures were observed in the study.

Also in agreement with MOBILIZE Boston, total SPPB score was not predictive of injurious falls in the Boston RISE cohort. Nor did the gait speed component or balance component of the SPPB predictive of injurious falls. In the balance model, there was a significantly increased hazard of fall injury associated with a score of 0 as compared to a score of 1, but the significance of this finding should be interpreted with caution given the small sample size of those with a score of 0 (n=4). While individual studies have reported that dynamic balance tests can predict falls, static tandem stance has not been associated with falls in prior reports.^{25, 26} Therefore, it is not surprising that the SPPB balance component score, which entails a progression of 3 static stance positions, was also not predictive of injurious falls. Despite previous findings linking gait speed to fall counts,²⁷ gait speed was not predictive of injurious falls in either MOBILIZE Boston or the present study. This finding suggests that the components that make chair stand performance different than gait speed performance may be linked to injury causality. Thus, future work, considering fall injury prevention, should evaluate the physiologic, behavioral and cognitive factors that drive the performance of these tasks.

Another finding of the present analysis was that DSST score was a significant model predictor, suggesting that deficits in psychomotor speed and working memory are important risk factors particularly in those with preexisting mobility limitations. While impaired attention and executive function have been shown to predict falls,²⁸ the findings of this analysis suggest they predict injurious falls as well. In a previous analysis of the Boston RISE cohort, those with non-amnestic cognitive impairment (i.e. meaningful executive function impairment) had significantly poorer mobility on both physical performance measures (including the SPPB) and self-reported mobility measures at baseline.²⁹ The

findings in this cohort add to a growing body of research showing that impairments in processing speed and executive function are linked with poor mobility outcomes.

This study does have some limitations. As mentioned, the method of fall injury data collection (retrospective quarterly phone calls), combined with the fact some participants could not be reached at each quarter, may have led to underestimation of fall injuries. Another potential limitation is that patients were allowed to define “injury” for themselves. For some patients, this may have resulted in overreporting of injurious falls since participants may have reported small injuries (such as localized pain or bruising) that may not have had any large impact on function or quality of life. For other patients, this may have resulted in underreporting of events, as some patients could subconsciously forget or overlook significant injuries. In addition, given that the cohort was predominantly white older adults at risk for mobility decline, the results may not be generalizable to all community-dwelling older adults. Finally, the models were based on the time to first reported fall injury, and do not address the question of which factors are associated with future risk of *recurrent* fall injuries. Nonetheless, this study has multiple strengths. The study population was selected as a particular at-risk population, so the results are more applicable to individuals with known mobility decline than results from population-based studies. Incidence of fall-related injury was also followed over two years, a clinically relevant time period, as primary care physicians generally perform overall assessments of the health of their patients at annual to biannual visits.

Conclusion

Among this cohort of older adults primary care patients, inability to perform a repeated chair stand task was associated with an increased hazard of fall-related injury over two years. This finding strengthens previous assertions that the chair stand task is a valid tool for stratifying risk of injurious falls. Questions for future research to address include whether using chair stand performance as an indication for intervention decreases morbidity, disability, or mortality and whether trajectories in chair stand task performance could be a valid measure of response to rehabilitative therapies.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

This work was supported by the National Institute on Aging (R01 AG032052-03), Eunice Kennedy Shriver National Institute of Child Health and Human Development (1K24HD070966-01), and the National Center for Research Resources in a grant to the Harvard Clinical and Translational Science Center (1 UL1 RR025758-01)

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Figure 1. Incidence of fall injury for participants unable vs. able to perform chair stand task (holding other model covariates constant at gender=female [most prevalent gender in cohort], race=white [most prevalent race in cohort], age=76.6 [mean participant age], DSST score =36.3 [mean score], fall history=no [most common in cohort]).

Table 1

Baseline characteristics of Boston RISE participants with and without reported fall injuries over 2-year study period (n=430).

Characteristic	No reported fall injuries (N=293)	At least one reported fall injury (N=137)	P-value
Age	76.3 (7.1)	77.1 (6.9)	0.27
BMI	29.5 (6.0)	29.4 (6.7)	0.90
ABC score (0–100)*	79.4 (21.3)	76.6 (25.6)	0.17
DSST score (0–73)	36.7 (11.1)	35.4 (11.0)	0.23
MMSE score (0–30)*	28 (3)	28 (3)	0.97
Male	34.1% (100)	28.5% (39)	0.24
White	79.2% (232)	89.8% (123)	0.01
Fall history (at least one fall during the year prior to baseline)	37.7% (110)	52.2% (71)	0.005
Education (high school graduate)	87.7% (257)	86.9% (119)	0.80
Use of sedating medications	28.3% (83)	34.3% (47)	0.21
Depressive symptoms	5.8% (17)	8.0% (11)	0.38
Peripheral sensory loss	27.9% (80)	31.9% (43)	0.40
Visual impairment	5.5% (16)	2.2% (3)	0.14
SPPB			
Total SPPB score	8.8 (2.2)	8.6 (2.3)	0.47
Gait score*	4(1)	4(1)	0.98
Chair stand score*	2(2)	2(2)	0.83
Balance score*	4 (2)	3 (2)	0.17

BMI=body mass index, ABC= Activities-Specific Balance Confidence, DSST= Digit Symbol Substitution Test, MMSE= Mini-Mental State Examination, SPPB= Short Physical Performance Battery. Values are mean (standard deviation) for normally distributed numeric variables, median (interquartile range) for non-normally distributed numeric variables (marked with *), and % (n) for categorical variables. T-tests were performed for normally distributed numeric variables, Mann-Whitney U tests were performed for non-normally distributed numeric variables, and χ^2 tests for categorical variables (Fischer's exact test was used for cell sizes less than 5). Missing data: fall history (n=2), DSST score (n=1), peripheral sensory loss (n=8), visual impairment (n=6).

Hazard of fall-related injury according to total Short Physical Performance Battery (SPPB) score and baseline characteristics.

Table 2

Model 1: With SPPB total score (c= 0.629 AIC=1060.2)	
Predictor	Hazard Ratio (95% Confidence Interval)
SPPB score	
Low vs. middle functioning	1.16 (0.72–1.86)
Low vs. high functioning	1.04 (0.64–1.68)
Middle vs. high functioning	0.89 (0.60–1.32)
Age	1.01 (0.98–1.03)
Male	0.68 (0.47–1.00) *
White	2.23 (1.25–3.99) *
Fall history	1.52 (1.08–2.14) *
DSST score	0.98 (0.96–1.00) *

DSST= Digit Symbol Substitution Test. Total SPPB score was divided into low functioning (4–6 points), middle functioning (7–8 points), and high functioning (9–12 points) groups.

* Significant at p<0.05.

Table 3

Hazard of fall-related injury according to Short Physical Performance Battery (SPPB) component scores and baseline characteristics.

Predictor	Model 2: Gait Speed (c= 0.626 AIC=1062.3)	Hazard Ratio (95% Confidence Interval)	Model 3: Balance (c= 0.638 AIC=1060.1)	Model 4: Chair Stand (c= 0.646 AIC=1056.5)
Score				
0 vs. 1	-	3.81 (1.09–13.35) *	2.40 (1.25–4.60) *	
0 vs. 2	-	2.88 (0.86–9.68)	2.34 (1.27–4.31) *	
0 vs. 3	-	2.55 (0.74–8.75)	2.00 (1.09–3.66) *	
0 vs. 4	-	3.30 (0.98–11.13)	1.70 (0.89–3.22)	
1 vs. 2	1.04 (0.23–4.64)	0.76 (0.41–1.39)	0.98 (0.57–1.66)	
1 vs. 3	1.19 (0.28–5.16)	0.67 (0.35–1.27)	0.84 (0.50–1.40)	
1 vs. 4	1.06 (0.25–4.57)	0.87 (0.47–1.58)	0.71 (0.40–1.24)	
2 vs. 3	1.15 (0.63–2.12)	0.89 (0.53–1.50)	0.85 (0.53–1.37)	
2 vs. 4	1.02 (0.58–1.81)	1.15 (0.72–1.82)	0.72 (0.43–1.21)	
3 vs. 4	0.89 (0.58–1.36)	1.29 (0.80–2.08)	0.85 (0.51–1.41)	
Age	1.01 (0.98–1.04)	1.01 (0.98–1.03)	1.00 (0.98–1.03)	
Male	0.68 (0.46–1.00) *	0.67 (0.46–0.99) *	0.70 (0.47–1.02)	
White	2.19 (1.23–3.93) *	2.32 (1.29–4.18) *	2.47 (1.38–4.44) *	
Fall history	1.52 (1.08–2.15) *	1.55 (1.09–2.18) *	1.49 (1.06–2.10) *	
DSST score	0.98 (0.96–1.00) *	0.98 (0.96–1.00) *	0.98 (0.96–1.00) *	

DSST= Digit Symbol Substitution Test.

* Significant at p<0.05.

Table 4

Hazard of fall-related injury according to chair stand ability.

	Model 5: Chair Stand ($c=0.640$ AIC=1052.5)
Predictor	Hazard Ratio (95% Confidence Interval)
Inability to perform chair stand	2.11 (1.23–3.62) *
Age	1.00 (0.98–1.03)
Male	0.68 (0.47–1.00) *
White	2.45 (1.36–4.41) *
Fall history	1.49 (1.06–2.09) *
DSST score	0.98 (0.96–1.00) *

DSST= Digit Symbol Substitution Test.

* Significant at $p<0.05$.