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Original Research

Risk Factors Associated With Falls and Fall-Related Injuries Among Wheelchair Users With Spinal Cord Injury

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KEYWORDS
Accidental falls;
Rehabilitation;
Risk factors;
Spinal cord injuries;
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Abstract *Objective:* To identify risk factors for falls and fall-related injuries for wheelchair users with spinal cord injury (SCI).
Design: Cross-sectional study.
Setting: Community setting.
Participants: Fifty-nine community dwelling wheelchair users (N=59), 47.5% male, median age of 52.5 years (IQR, 21 years) with chronic SCI, median time since injury of 16.6 years (IQR, 27.3 years).
Interventions: No intervention.
Main Outcome Measures: Outcomes were incidence of falls and fall-related injuries. Participants reported on falls and fall-related injuries experienced in the previous 6 months. Independent variables were self-reported and performance-based measures. Self-reported measures included demographics, characteristics of SCI, fear of falling, psychological measures, functional independence, wheelchair skills, environmental barriers, quality of life, and community participation. Performance-based measures included transfer quality and sitting balance assessments. Logistic regression analyses were conducted to identify factors influencing falls and fall-related injuries.
Results: In total, 152 falls and 30 fall-related injuries were reported from a total of 37 fallers. After logistic regression analysis, the model with the greatest levels of clinical utility and discriminative ability for falls (sensitivity 81%; specificity 55%; area under the receiving operating characteristic curve [AUC] statistics=0.73; 95% CI, 0.60-0.86) included the variables of shorter time since SCI, high mobility level, and having received education on fall prevention. The model for fall-related injuries (sensitivity 79%; specificity 75%; AUC statistics=0.77; 95% CI, 0.59-0.96)

List of abbreviations: ADL, activities of daily living; AIS, American Spinal Injury Association Impairment Scale; AUC, area under the receiver operating characteristic curve; FOF, fear of falling; OR, odds ratio; QOL, quality of life; SCI, spinal cord injury; SCIM III, Spinal Cord Independence Measure III; TAI, Transfer Assessment Instrument; WHOQOL-BREF, World Health Organization Quality of Life-Brief Version; WST, Wheelchair Skill Test.

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included the variables of older male individual, lower physical health score, and having received education on fall prevention.

Conclusions: The regression models presented may be used to identify wheelchair users with SCI at greater risk of falls and fall-related injuries. The findings may help to refer those in need to tailored fall and fall-related injury prevention programs. The findings presented in this study were based on a relatively small sample convenience; therefore, further prospective studies with a larger sample size are warranted.

Falls are common among individuals living with spinal cord injury (SCI). A recent review estimated that approximately 69% of nonambulatory individuals with SCI experience at least 1 fall in a period of 6-12 months.[1] Overall, the consequences of falls are far reaching, resulting in individual and societal burdens. Those consequences include physical injuries, fear of falling (FOF), and associated activity curtailment.[2-4] Falls resulting in physical injuries might lead to immobility and bed dependency, which in turn may result in secondary complications, such as pressure ulcers.[5] Falls are therefore associated with an increased need for health care utilization contributing to a high socioeconomic cost.[2-4]

The effectiveness of fall prevention programs depends on, among other factors, the appropriate identification of the risk predictors for falls. For this purpose, reliable screening tools are essential to allow early identification of individuals with SCI at risk of falls and refer them for appropriate fall preventions programs. Among nonambulatory individuals with SCI, few studies have specifically investigated potential fall risk predictors.[6-8] Those predictors include pain, alcohol abuse, greater motor function, previous falls, number of SCI years, and shorter length of wheelchair, previous recurrent falls, age, and male sex.[6-8]

Moreover, pain, greater motor score, previous falls, home entrance inaccessibility, and quality of life (QOL) were identified as predictors of fall-related injuries.[6,7] As evidenced above, only 3 studies[6-8] have specifically investigated fall predictors, and only 2 have examined predictors of falls associated with injury in this population.

Consequently, there is a limited understanding of fall risk factors specific for wheelchair users with SCI, ultimately leading to a lack of evidence-based approaches to fall prevention and a reliable fall screening tool to identify individuals at risk of falls in clinical settings. Thus, the purpose of this study is to determine factors associated with falls and fall-related injuries among nonambulatory individuals with SCI. In addition, the study aimed to determine which combination of self-reported and performance-based outcome measures presents with the highest level of discriminant ability to identify individuals at risk of falls and fall-related injuries in this population.

Methods

This is a cross-sectional observational study design. An online survey was conducted between January 2021 and July 2021 in the United States using the Research Electronic Data Capture[9] survey platform. In addition to the survey, sitting balance and transfer abilities were assessed remotely. The study was reviewed and approved by the Office for the Protection of Research Subjects at the University of Illinois, Urbana-Champaign (#20718). All participants provided remote informed consent before taking part in the study. The informed consent document was sent to potential participants electronically through Research Electronic Data Capture (REDCap). They were instructed to read and asked any follow-up questions to the research team, if necessary, before signing the informed consent document.

A convenience sample of individuals with SCI were recruited to participate in the study. Participants were recruited from SCI support groups across the United States, Facebook posts, personal communication, and magazine or newsletter advertisements. Participants were invited to take part in the study if they met the following inclusion criteria: (1) 18 years or older with a chronic SCI for at least 12 months after injury, (2) motor complete injury classified as American Spinal Injury Association Impairment Scale (AIS) A or B and motor incomplete injury AIS C who are wheelchair users, (3) level of injury between C5 and above L5, (4) self-report use of a wheelchair for at least 75% of mobility, (5) able to communicate with the research team through smartphone or laptop video conferencing software, and (6) able to understand English. Participants were excluded if they presented with any additional medical conditions that might affect their ability to perform the tests. Individuals with AIS D and E were excluded because they present with motor incomplete injury.

Because of the restrictions placed on human participant research because of the COVID-19 pandemic, all testing procedures were performed remotely. Figure 1 illustrates the steps for the study procedures. After screening for eligibility criteria, participants completed a demographic survey, surveys on falls and fall-related injuries, and questionnaires described in outcome measures. After completion of the online surveys, participants and a researcher met over a video call to perform sitting balance and transfer testing with the assistance of a family member, caregiver, or friend.

Outcome measures

Participants first completed the following self-reported outcome measures:

1. Demographics, characteristics of SCI, and a survey to collect information on the frequency of falls and fall-related injuries experienced by the participants in the

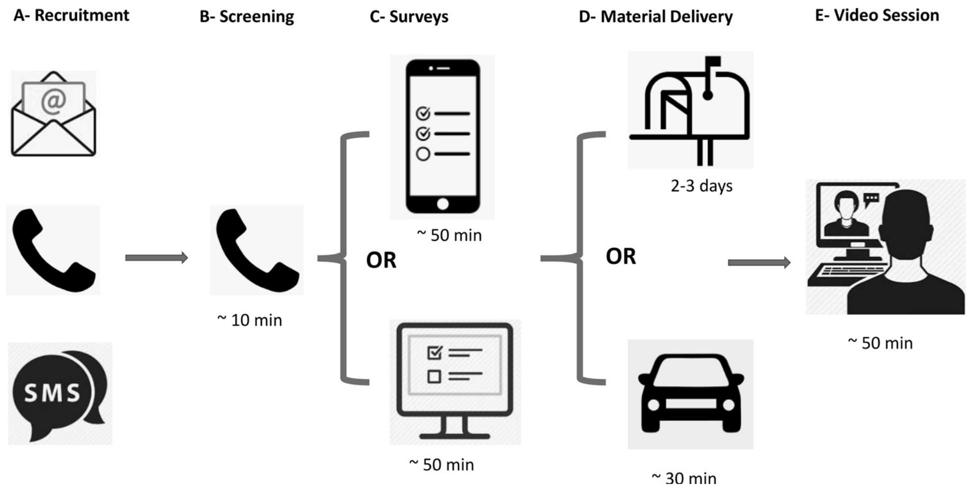

Fig 1 (A) Potential participants contacted the research group and manifested their interest in participating in the study. (B) Potential participants were screened over the phone for eligibility criteria by a researcher. (C) Eligible participants were provided with a link to complete demographics and surveys. (D) A researcher delivered assessment packages to study participants who completed the surveys through drop-off or mail. (E) Participants met with the researcher to perform remote sitting balance and transfer assessments.

previous 6 months. A fall was defined as an unintentional event in which one comes to rest on the ground, floor, or other lower level.[10] Participants also responded to a question about whether they ever received education on fall prevention from a health care professional.

2. Fear of falling: Participants responded "yes" or "no" to a question developed to assess FOF[11]: "Are you worried or concerned that you might fall?" In addition, participants completed the SCI Falls Concern Scale questionnaire.[12]
3. Psychological measures: The Hospital Anxiety and Depression Scale was used to assess symptoms of depression and anxiety.[13]
4. Functional independence: The Spinal Cord Independence Measure (SCIM) III was used to evaluate functional independence.[14] The SCIM III assesses domains related to self-care, respiration and sphincter control, and mobility.
5. Environmental barriers: The Craig Hospital Inventory of Environmental Factors-Short Form was used to quantify environmental barriers.[15]
6. Wheelchair skills: The Wheelchair Skills Test 5.0 questionnaire (WST-Q) was used to assess wheelchair skills.[16] The Wheelchair Skills Test 5.0 questionnaire evaluates domains such as frequency, confidence, and performance.
7. Quality of life: The World Health Organization Quality of Life-Brief version (WHOQOL-BREF) was used to quantify QOL.[17] The WHOQOL-BREF evaluates domains of physical health, psychological health, social relationships, and environment.
8. Community participation: The Community Participation Indicators questionnaire was used to assess participants' community participation.[18] The questionnaire evaluates the following domains: importance of participation and control over participation.

After the completion of the self-reported measures, participants' sitting balance was evaluated remotely using the Function in Sitting Test,[19,20] Trunk Control Test,[21,22] T-shirt Test,[23,24] and modified Functional Reach Test.[22,25] A paper ruler that was sent to the participants was used to estimate reaching distance during the modified Functional Reach Test. The validity and reliability of remote assessment of sitting balance measures have been fully described elsewhere.[26] An assessment of transfer quality was performed using the Transfer Assessment Instrument (TAI).[27,28] The procedures for the remote TAI assessment are also fully described elsewhere.[27,28] A paper goniometer sent to the participants was used during the TAI evaluation. Finally, participants completed a self-assessment of their transfer assessment using the self-TAI.[29]

Statistical analyses

Data were coded, entered, and analyzed using IBM SPSS Statistics version 25.[a] Counts and frequencies were used to describe categorical variables, and normality of data was assessed using the Kolmogorov-Smirnov test. Because of the nonnormal distribution, Mann-Whitney *U* tests were used to examine differences in continuous variables. The associations between fall status and categorical independent variables were tested using chi-square or Fisher exact tests.

Multivariable logistic regression analyses were conducted to examine factors associated with falls and fall-related injuries. Number of falls reported by participants was regarded as the dependent variable of the study, dichotomized as 0 fall (nonfaller) or ≥1 (faller). Fall-related injuries were also used as a dependent variable and dichotomized as 0 injury (no injury) or ≥1 injury (injury). Individual missing data were excluded on a case-by-case basis from the analysis.

Independent variables were selected based on the results of previous studies.[6,7] Correlation between variables was examined using Spearman rank correlation (ρ). To avoid collinearity in the multivariable logistic regression models and to reduce the number of independent variables, variables with correlation <0.4 were entered in the bivariate analysis. For variables assessing similar constructs even if the correlation was <0.4, only the one with lowest *P* value was included in the full logistic model. All variables with a *P* value ≤.15 from the bivariate analysis were considered for inclusion in the logistic regression analysis. This value of ≤.15 was chosen because it is recommended when using regression analysis in smaller cohorts and ensured no relevant variable was left out of the model.[30]

Two logistic regression models (full and final) were built for each dependent variable. The logistic regression models were analyzed with final independent variables assessed at a *P* value <.05. Model building was iterative and guided with interpretability, parsimony, and the evaluation of the Wald statistic for each variable at each step. Goodness-of-fit of the final reduced model was assessed using the Hosmer and Lemeshow test and the Nagelkerke R^2 value. Odds ratios (ORs) and 95% CIs were reported for factors associated with falls and fall-related injuries. Receiver operating characteristic curve analysis was carried out to select the optimal cutoff point to dichotomize the composite measure of the logistic regression model and the continuous variables. The area under the receiving operating characteristic curve (AUC) statistic value was estimated. AUC statistic values >0.7 were considered appropriate to discriminate between 2 groups.[31]

Results

A total of 70 eligible individuals agreed to participate in the study. Of the 70 participants, 11 did not provide any data and were excluded from the analysis. Fifty-nine individuals were included in the analyses. The demographics and clinical information of the participants are presented in tables 1 and 2, respectively. No significant differences were observed for demographics and clinical information between fallers and nonfallers.

A total of 152 falls were reported in the 6 months prior to data collection: 22 participants (37%) did not experience a fall and were categorized as nonfallers, and 37 (63%) experienced at least 1 fall and were categorized as fallers. Also, from the 37 participants who experienced at least 1 fall, data on the most recent injuries associated with a fall were available for 30 participants. From those 30, a total of 14 (46.7%) reported fall-related injuries and 16 (53.3%) did not report any fall-related injuries after the fall.

After bivariate logistic analysis for fall variable, 8 potential predictor variables presented with a *P* value ≤.15 and were deemed suitable for further multivariable logistic analysis (appendix 1): sex, time since injury, recurrent fallers (>2 falls), SCIM III self-care, SCIM III mobility, and SCIM III total score. In addition, age was added as a confounder predictor and education on fall prevention was included as a variable of interest. After analysis for multicollinearity, 5 variables (age, time since injury, recurrent falls, SCIM III mobility score, and education on falls) were included in the full multivariable logistic regression analysis (table 3).

Table 3 also shows the final multivariable logistic regression model with 3 associated factors. The results indicate that participants with shorter time since SCI had approximately 1-time higher odds of being fallers than those with longer time since SCI. Also, participants with greater mobility levels in the SCIM III had 1.16 higher odds of being fallers than those with lower mobility levels in the SCIM III. The AUC statistic (fig 2) of the final model was 0.73 (95% CI, 0.60-0.86, *P*<.01). This is higher than the AUC values of the included variables in isolation (see table 3). The model's sensitivity and specificity at an optimal cutoff of 0.53 were estimated at 81% and 55%, respectively. The model had a good fit (Hosmer and Lemeshow test, *P*=.30, Nagelkerke R^2=0.22).

After bivariate logistic analysis for fall-related injuries variable, there were 5 potential predictor variables with a *P* value ≤.15 that were deemed suitable for further full

Table 1 Characteristics of study participants

Characteristic	Total Sample (N=59)	Fallers (n=37, 63%)	Nonfallers (n=22, 37%)	*P* Value
Sex, n (%), male; female	28 (47.5); 31 (52.5)	21 (56.8); 16 (43.2)	7 (31.8); 15 (68.2)	.06
Age (y), median (IQR); min-max	52.5 (21); 19-72	51 (22); 19-69	53 (17); 26-72	.23
Race, n (%), Asian; Black; White; Hispanic	3 (5.1); 6 (10.2); 48 (81.4); 2 (3.4)	3 (8.1); 4 (10.8); 29 (78.4); 1 (2.7)	0 (0.0); 2 (9.1); 19 (86.4); 1 (4.5)	.56
Height (cm), mean (SD); min-max	171.5 (17.1); 137.2-190.5	173.0 (19.0); 137.2-190.5	170.2 (19.0); 147.3-188.0	.77
Weight (kg), median (IQR); min-max	75 (27); 42-125	71.4 (29); 42-120	78 (26); 55-125	.33
Mobility aid, n (%), power WC; manual WC	17 (28.8); 42 (71.2)	8 (21.6); 29 (78.4)	9 (40.9); 13 (59.1)	.11
Cause of SCI, n (%), traumatic; nontraumatic	43 (72.9); 16 (27.1)	25 (67.6); 12 (32.4)	18 (81.8); 4 (18.2)	.23
Time since injury (y), median (IQR); min-max	16.5 (27.3); 0.5-57	11 (27.8); 1-54	23.5 (27.3); 0.5-57	.06
Level of injury, n (%), cervical; high thoracic; low thoracic; lumbar; unknown	13 (22.0); 15 (25.4); 22 (37.3); 5 (8.5); 4 (6.8)	5 (13.5); 12 (32.4); 14 (37.8); 3 (8.1); 3 (8.1)	8 (36.4); 3 (13.6); 8 (36.4); 2 (9.1); 1 (4.5)	.24

NOTE. Results are expressed as frequencies and percentages for categorical variables and mean ± SD or median (IQR) for continuous variables.
Abbreviation: WC, wheelchair.

Table 2 Clinical information of study participants

Characteristic	Total Sample (N=59)	Fallers (n=37, 63%)	Nonfallers (n=22, 37%)	*P* Value
Education on fall prevention, n (%),* yes; no	30 (57.7); 22 (42.3)	16 (53.0); 14 (47.0)	14 (64.0); 8 (36.0)	.36
FOF, n (%), no; yes	16 (27.0); 43 (73.0)	13 (81.0); 24 (56.0)	3 (19.0); 19 (44.0)	.07
SCI-FCS, n (%)	28 (14)	30 (11)	24 (8)	.18
HADS, median (IQR), Depression; Anxiety	5 (5); 5 (6)	3 (4); 4 (7)	7 (3); 9 (4)	.78; .57
Balance measures,† FIST; TCT; T-shirt Test (s); mFRT (cm); Self-TAI; TAI	44 (12); 22 (7); 4.8 (2.7); 10.8 (7.8); 6.9 (1.7); 8.2 (1.1)	44 (12); 23 (7); 5.2 (3.6); 10.8 (7.2); 6.9 (1.8); 8.0 (1.2)	43 (6); 19 (4); 4.2 (0.1); 7.0 (7.1); 7.3 (0.4); 8.5 (0.3)	.73; .55; .39; .33; .73; .47
Community participation; CPI-Importance; CPI-Control	50 (15); 55 (8)	48 (17); 55 (9)	50 (9); 55 (9)	.28; .96
CHIEF-SF, median (IQR)	21 (16)	21 (15)	21 (16)	.60
SCIM III, median (IQR), self-care; respiration and sphincter control; mobility; total	18 (3); 28 (13); 16 (6); 62 (16)	18 (2); 29 (11) 16 (4); 62 (14)	18 (7); 27 (13) 15 (9); 62 (25)	.43; .49 .09; .32
WST, median (IQR), capacity; confidence; performance	83 (22); 82 (21); 65 (31)	82 (18); 81 (21); 69 (31)	80 (30); 81 (25); 63 (29)	.51; .61 .68
WHOQOL, median (IQR), physical health; psychological health; social relationships; environment	65 (11); 69 (12); 65 (31); 88 (25)	63 (24); 69 (14); 65 (31) 81 (27)	65 (6); 69 (17) 69 (27); 88 (22)	.25; .28 .22; .34

NOTE. Results are expressed as frequencies and percentages for categorical variables and median (IQR) for continuous variables. N=59 unless otherwise stated.
Abbreviations: CHIEF-SF, Craig Hospital Inventory of Environmental factors-Short Form; CPI, community participation indicator; FIST, Function in Sitting Test; HADS, Hospital Anxiety and Depression Scale; mFRT, Modified Functional Reach Test; SCI-FCS, Spinal Cord Injury-Falls Concern Scale; TCT, Trunk Control Test; WHOQOL, World Health Organization Quality of Life; WST, Wheelchair Skills Test.
* n=52.
† n=18.

multivariable logistic regression analysis (appendix 2). These factors included age, sex, WHOQOL physical health, Craig Hospital Inventory of Environmental Factors-Short Form, and education on fall prevention (table 4). Sex was included because it was regarded as a confounder. Also, education on fall prevention was included.

Table 4 also shows the final multivariable logistic regression model with 4 predictor-associated factors. The results indicate that for each unit increase in WHOQOL physical health (higher score on physical health domain of quality of life), the OR of experiencing a fall-related injury decreases by 8% (OR, 0.92; *P*=.04). The AUC statistic (fig 3) of the final model was 0.77 (95% CI, 0.59-0.96, *P*=.01). This is higher than the AUC values of the included variables in isolation (see table 4). The model's sensitivity and specificity at an optimal cutoff of 0.37 were estimated at 79% and 75%, respectively. The model had an adequate fit (Hosmer and Lemeshow test, *P*=.05, Nagelkerke R^2=0.39).

Discussion

This research investigated factors associated with falls and fall-related injuries among nonambulatory individuals with SCI. After analyzing a broader range of variables compared with previous studies,[6-8] time since injury and SCIM III mobility score were found to be significant risk indicators for falls in this population. The model containing these indicators

Table 3 Full and final models for multivariate logistic regression analysis (N=59) to identify individuals with SCI at risk of falls

Variable	Full Model			Final Model			
	P Value	β	OR (95% CI)	*P* Value	β	OR (95% CI)	AUC Value (95% CI)
Constant	-	-	-	.32	−1.06	0.35	-
Time since injury	.08	−0.04	0.96 (0.92-1.01)	.04*	−0.05	0.96 (0.92-0.99)	0.35 (0.21-0.50)
SCIM III mobility	.03	0.16	1.17 (1.01-1.36)	.03*	0.15	1.16 (1.01-1.33)	0.63 (0.48-0.78)
Education on falls: yes	.22	0.81	2.25 (0.62-8.11)	.15	0.92	2.52 (0.71-8.88)	0.44 (0.28-0.59)
Age	.65	−0.01	1.00 (0.94-1.04)	-	-	-	-
Recurrent fallers: yes	.16	−0.92	0.40 (0.11-1.47)	-	-	-	-

* $P < 0.05$.

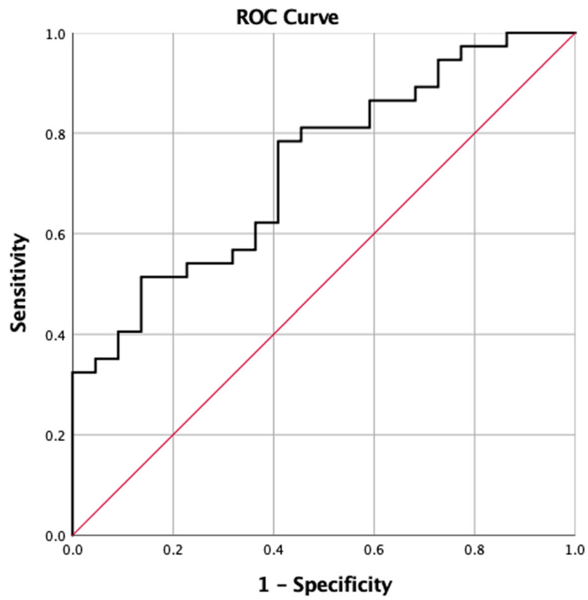

Fig 2 ROC analysis of the final model for risk of falls, AUC=0.73 (95% CI, 0.60-0.86), *P*<.01. Abbreviation: ROC, receiver operating characteristic.

presented with a sensitivity of 81%, specificity of 55%, and AUC statistic value of 0.73 (95% CI, 0.60-0.86). In addition, the physical health domain of WHOQOL was found to be the only significant risk indicator for fall-related injuries. The model containing the WHOQOL-physical health presented with a sensitivity of 79%, specificity of 71%, and AUC statistic value of 0.77 (95% CI, 0.59-0.96). These findings provide further, insight on factors associated with falls and fall-related injuries in this population. This information is useful to improve the ability of clinicians to identify individuals at risk for falling and develop fall risk screening tools for this population. In addition, the identification of factors associated with falls may be used to inform the development of effective fall prevention programs.

Notably, shorter time since SCI and greater mobility function reported in our study as factors associated with falls align with the predictors previously highlighted by Nelson et al[7] in this population. Individuals with more recent onset of SCI are often adults who are highly active, engaging in both basic and instrumental activities of daily living (ADL). Engaging in ADL with few experiences using a wheelchair might lead to an increase exposure to falls. Also, individuals with greater mobility function are generally more independent and more engaged in their ADL, which might lead to falls. Other studies have also highlighted greater mobility function,[8] higher level of ability,[32] and higher levels of physical activity[33] as predictors of falls in individuals with SCI. Other fall predictors, such as pain in the previous 2 months, alcohol abuse, and a shorter length of wheelchair reported by Nelson et al,[7] were not examined in our study. However, the model presented in our study, with 2 factors, achieved a sensitivity of 81% and an AUC of 0.73. While our model presented with good discriminant ability and sensitivity, the moderate specificity (55%) indicates that some nonfallers may be incorrectly identified as fallers using our model. These individuals might be unnecessarily referred to fall prevention programs. This unnecessary referral to fall prevention programs will only benefit these individuals to improve their knowledge about fall prevention.[34,35] Nonetheless, our model will allow clinicians to identify most individuals at risk of falls, communicate the probability of falling to these individuals, and refer them to appropriate fall prevention programs.

The subanalysis of those who experienced at least 1 fall indicates that WHOQOL-physical health was the only factor associated with fall-related injuries among nonambulatory individuals with SCI. This finding suggests that increased scores on the physical health domain of the WHOQOL questionnaire was associated with decreasing odds of having a fall-related injury. The physical health domain of the WHOQOL questionnaire evaluates components related to energy and fatigue, mobility, physical pain and discomfort, sleep and rest, work capacity, performance of ADL, and medication.[17] For example, pain and discomfort may lead to a dysfunctional seated posture in a wheelchair, resulting in decreased efficiency in movements during transfers or reaching for an object, which could contribute to an increased risk of sustaining an injury after a fall. Considering the components evaluated by the physical health domain of the WHOQOL during fall risk screenings is important to appropriately identify individuals at risk of fall-related injuries.

Our results align with the report by Forslund et al,[6] who indicated general QOL as the only predictor of fall-related injury in this population. Because QOL is broad, our results add to knowledge about the specific domain (physical health) associated with fall-related injuries. Moreover, our

Table 4 Full and final models for multivariate logistic regression analysis (N=59) to identify individuals with SCI at risk of fall-related injury

Variable	Full Model			Final Model			
	P Value	β	OR (95% CI)	*P* Value	β	OR (95% CI)	AUC Value (95% CI)
Constant	-	-	-	.60	−1.06	0.92	-
WHOQOL-PH	.09	−0.07	0.93 (0.86-1.01)	.04*	−0.05	0.92 (0.85-0.99)	0.34 (0.14-0.54)
Age	.08	0.09	1.09 (0.99-1.21)	.07	0.15	1.08 (0.99-1.18)	0.64 (0.43-0.85)
Sex: Female	.05	−2.21	0.11 (0.01-1.02)	.12	0.92	0.20 (0.03-1.49)	0.60 (0.40-0.81)
Education on falls: Yes	.91	−1.08	0.34 (0.13-6.03)	.92	−0.10	0.91 (0.14-5.91)	0.54 (0.33-0.75)
CHIEF-SF	.10	−0.08	0.92 (0.85-1.01)	-	-	-	-

Abbreviation: WHOQOL-PH: World Health Organization Quality of Life-physical health.
* $P < 0.05$.

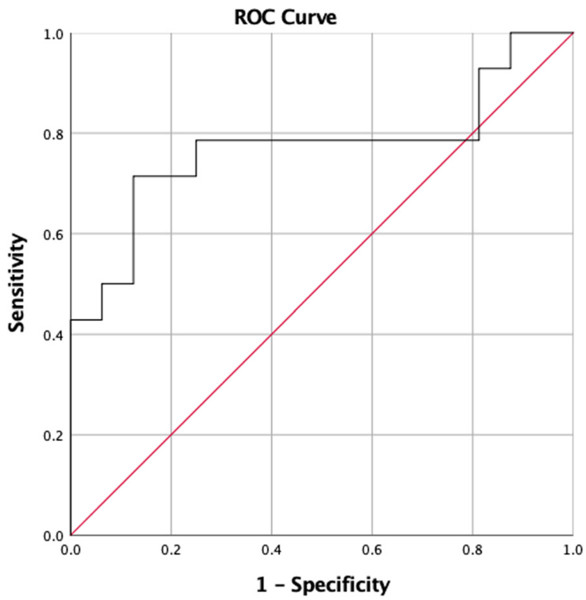

Fig 3 ROC analysis of the final model for fall-related injury, AUC=0.77 (95% CI, 0.59-0.96), *P*=.01. Abbreviation: ROC, receiver operating characteristic.

findings presented with a sensitivity and specificity of 79% and 75%, respectively, and an AUC of 0.77, indicating good discriminant ability of the model. The alignment between our results and the findings by Forslund et al[6] indicates that clinicians might use the physical health domain of WHOQOL-BREF to identify nonambulatory individuals at risk of falls and refer them to appropriate fall prevention programs.

Surprisingly, having received education on fall prevention was not found as a factor associated with fall related outcomes. Although, this is the first study to analyze this variable as a potential risk factor, the findings suggest that the current education on fall prevention for individuals with SCI may not be affecting fall-related outcomes. The interpretation of this finding was somewhat limited because the specific components, length of the educational programs, and which professional provided the education received by the participants was not investigated and details on those programs were lacking. However, further examination of the influence of fall prevention programs on fall-related outcomes is needed to inform clinicians whether improvement of those programs is necessary.

Compared with ambulatory individuals with SCI among whom performance-based measures have shown ability to differentiate between fallers and nonfallers,[36,37] performance-based measures such as balance measures including the Function in Sitting Test, Trunk Control Test, or TAI were not found to be associated with falls and fall-related injuries among nonambulatory individuals with SCI. This might be because of the lack of sensitivity of clinical performance-based measures used for nonambulatory individuals.[38] Efforts should be made by clinicians and researchers to improve the sensitivity of those outcome measures to facilitate their inclusion in research and clinical settings. Also, the complexity of falls from a wheelchair might explain the absence of associations between clinical performance-based measures and falls among nonambulatory individuals. Although the performance-based measures evaluated in this study were not significant to identify individuals at risk of falls, findings from qualitative research highlight the importance of these measures. Participants often report poor balance, transfers, and reaching for items to be associated with falls.[6,39,40] Accurate prediction of falls from a wheelchair likely requires the integration of the factors associated with falls described in this study and the integration of findings from qualitative research described in previous studies.[6-8]

Study limitations

There are several limitations that should be considered in this study. First, we included a relatively small sample size in our study. Specifically, the subanalysis of fall-related injuries was performed with a small number of fallers. When comparing the literature on fall predictors among nonambulatory individuals with SCI to the existing literature on ambulatory individuals[36,37] or individuals with other neurologic diseases,[41,42] it becomes evident that further research with a bigger sample size is required to provide more robust findings. Another limitation is that our analyses were based on self-reported and retrospective fall data. Compared with prospective fall tracking, retrospective fall data may be influenced by recall bias, therefore limiting the interpretation of our results. Also, the sample of convenience might be affected by the respondent bias, which may hinder the evaluation of the representativeness of our sample. Lastly, we suspect that most participants underreported minor fall-related injuries. Future studies using emerging fall detection devices that will automatically and accurately detect and provide an objective report of falls might help to provide more robust findings.[43,44]

Conclusions

In summary, our findings confirm the need to increase awareness about falls and fall-related injuries in this population. During fall risk screenings, clinicians should consider time since injury and level of mobility, as well as components included in the physical health domain of the quality of life questionnaire, such as level of energy and reports of fatigue and physical pain. Carefully considering these findings and reports are important because they have been found to be associated with falls and fall-related injury, respectively. Identifying nonambulatory individuals with SCI at risk of falls will improve referrals to rehabilitation professionals for enrollment in fall prevention programs in a timely manner. Education on wheelchair-related falls should be incorporated in early stages of SCI rehabilitation process.

Supplier

a. SPSS Version 25.0 for Windows; SPSS Inc, Chicago, IL.

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