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Research

Falls and fear of falling predict future falls and related injuries in ambulatory individuals with spinal cord injury: a longitudinal observational study

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KEY WORDS

Incomplete spinal cord injury
Accidental falls
Incidence
Fall-related injury
Multivariate logistic regression

ABSTRACT

Question: What is the 1-year incidence of falls and injurious falls in a representative cohort of community-dwelling ambulatory individuals with chronic spinal cord injury? What are the predictors of recurrent falls (more than two/year) and injurious falls in this population? **Design**: One-year longitudinal observational multi-centre study. **Participants**: A representative sample of 68 (of 73 included) community-dwelling ambulatory individuals with traumatic SCI attending regular follow-up programs at rehabilitation centres. **Outcome measures**: Primary outcome measures were incidence and predictors of recurrent falls (more than two/year) and injurious falls reported every 2 weeks for 1 year. **Results**: A total of 48% of participants reported recurrent falls. Of the 272 reported falls, 41% were injurious. Serious injuries were experienced by 4% of participants, all of whom were women. Multivariate logistic regression analysis showed that recurrent falls in the previous year (OR = 111, 95% CI = 8.6 to 1425), fear of falling (OR = 6.1, 95% CI = 1.43 to 26) and longer time taken to walk 10 m (OR = 1.3, 95% CI = 1.0 to 1.7) were predictors of recurrent falls. Fear of falling (OR = 4.3, 95% CI = 1.3 to 14) and recurrent falls in the previous year (OR = 4.2, 95% CI = 1.2 to 14) were predictors of injurious falls. **Conclusion**: Ambulatory individuals have a high risk of falling and of fall-related injuries. Fall history, fear of falling and walking speed could predict recurrent falls and injurious falls. Further studies with larger samples are needed to validate these findings. **[Jørgensen V, Butler Forslund E, Opheim A, Franzén E, Wahman K, Hultling C, Seiger Å, Ståhle A, Stanghelle JK, Roaldsen KS (2017) Falls and fear of falling predict future falls and related injuries in ambulatory individuals with spinal cord injury: a longitudinal observational study. *Journal of Physiotherapy* XX: XX-XX]**

Introduction

Falls are common in ambulatory people with spinal cord injury (SCI). Reported incidences vary between 30 and 75%.[1–7] However, the large age span and a high proportion of risk takers[8] must be considered when studying falls in this population. The increasing number of ambulatory individuals with incomplete SCI and their increasing age at injury in the Western world[9,10] have raised concerns about falls and their adverse consequences. Reports of the incidence of fall-related injuries needing medical attention vary between 2 and 20%.[3–5,11,12] As injurious falls may increase with number of falls,[13] it is important to identify recurrent fallers. Moreover, infrequent or isolated falls are more unpredictable than recurrent falls, which are more likely linked to underlying neurological and musculoskeletal problems.[14]

A few studies have sought to establish predictors of falls.[3,7,15–17] The predictors that have been described include level of ability,[2,3,7,12,15] exercise level,[2,6,18] comorbidity, physical health, quality of life,[7,11,17,18] and fear of falling.[2] However, it is believed that the effect of challenging outdoor conditions during wintertime (as are common in Nordic countries) has not yet been studied.

Thus far, research findings are inconclusive, because previous fall studies in this population have been limited by small samples,[4,5] as well as weaknesses and diversity in both study designs[3,6,11,12] and recruitment processes.[2–7] Thus, incidence and predictors of falls and fall-related injuries have yet to be established.[19]

Therefore, the research questions for this longitudinal observational multi-centre study were:

1. What is the 1-year incidence of falls and injurious falls in a representative cohort of community-dwelling ambulatory individuals with chronic SCI?
2. What are the predictors of recurrent falls (more than two/year) and injurious falls in this population?

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Methods

Design

This 1-year, prospective study was part of a multi-centre study, conducted at Sunnaas Rehabilitation Hospital, Norway, and Rehab Station Stockholm/Spinalis, Sweden, called the Spinal Cord Injury Prevention of Falls (SCIP FALLS) Study. Participants were consecutively recruited between February 2013 and May 2014 in connection with a regular check-up in the systematic life-long follow-up program offered to all patients with SCI in the catchment areas of South-East of Norway and Greater Stockholm. The reporting of this study was guided by the TRIPOD[20] and STROBE[21] statements.

Participants and centres

Participants constituted the ambulatory subgroup of the SCIP FALLS Study (Figure 1). Data were collected in parallel in Norway and Sweden by two physiotherapists with >15 years of experience in SCI rehabilitation. The inclusion criteria were: traumatic SCI; being ≥1 year post injury; being aged ≥18 years; having the ability to cooperate and understand Norwegian/Swedish in speech and writing; and walking independently with or without walking aids for ≥75% of time for mobility needs,[22] according to the participants' own judgment of their ratio of wheelchair use to walking (0:100, 75:25, 50:50, 25:75 or 100:0). Five participants who stated that their ratio was 50:50 were discussed, and the research group classified them as ambulatory. The exclusion criteria were: SCI below L5 level or classified as American Impairment Scale (AIS) E (normal sensory and motor functions).[23] All participants gave written informed consent after receiving oral and written information.

The participants' characteristics (n = 68) are presented in Table 1. A total of 42 participants (62%) had a cervical lesion, 18 (27%) a thoracic lesion, and eight (12%) a lumbar lesion. Two participants (3%) were classified as AIS A, one (2%) as AIS B, three (4%) as AIS C and 62 (91%) as AIS D.[23] Twenty-nine participants (40%) used lower limb orthotic aids, 13 (19%) used walking aids indoors, while 26 (38%) used walking aids and five (7%) a wheelchair when moving outdoors.

Data collection

Outcomes

The outcomes of interest were falls and fall-related injuries. A fall was defined as 'an unexpected event in which the participants come to rest on the ground, floor, or lower level'.[24] Injurious falls were defined as falls leading to any kind of physical injury classified as: serious (medically recorded fracture, head or internal injury requiring accident and emergency or inpatient treatment); moderate (wounds, bruises, sprains, cuts requiring a medical/health professional examination such as physical examination, x-ray, suture); minor (minor bruises or abrasions not requiring health professional assistance, reduction in physical function (eg, due to pain, fear of falling), fear of falling for at least 3 days); or no injury (no physical injury detected).[25]

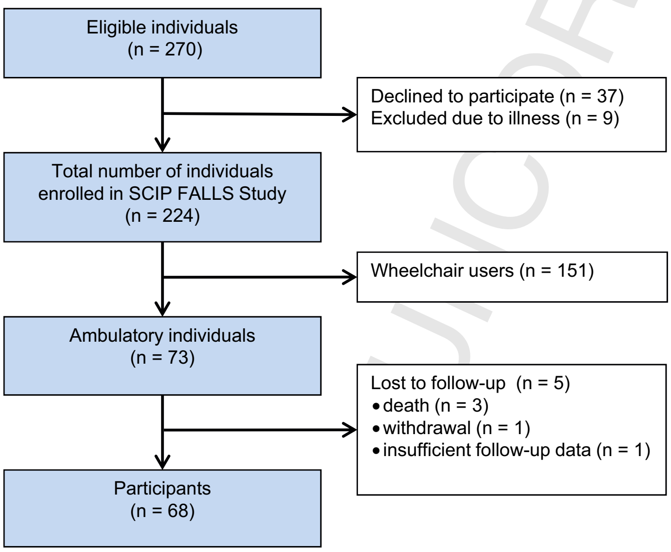

Figure 1. Participant flow in recruitment and follow-up.
SCIP FALLS Study = Spinal Cord Injury Prevention of Falls study.

Falls were monitored for 1 year by sending a text message via an online short message service (SMS) survey company[a] every second week, asking: 'Have you fallen in the past 2 weeks?' Participants who failed to answer this SMS and a reminder SMS sent 2 days later were contacted by telephone. If a participant's SMS reply was 'yes', a structured telephone interview was conducted within a week, focusing on number of falls, why, how, when and where they fell, as well as on possible injuries. All participants were telephoned 4, 8 and 12 months after baseline to maintain compliance and collect fall data.

Predictors

Due to the lack of consistent knowledge on falls and fall risk in ambulatory individuals with SCI, this study was exploratory. Hence, predictors were not selected a priori. Rather, data on a range of possible predictors were collected for the SCIP FALLS Study[7] based on previous studies (see Appendix 1 on the eAddenda). At a structured interview, the following data were recorded: socio-demographic data, injury-specific factors, secondary SCI conditions, number of prescription medications, history of recurrent falls in the previous year, ability to get up from the ground by oneself, fear of falling, monthly alcohol use, quality of life, and risk willingness. Clinical assessments included the International Standards for Neurological Classification of Spinal Cord Injury, use of walking aids, muscle strength in the lower extremities, functional independence, walking ability, balance, and exercise habits. Self-administrated questionnaires covered concerns about falling, fatigue, anxiety and depression, as well as health-related and general quality of life.

Data analysis

Thirty-nine falls directly related to sports activities (skiing, ice hockey and ball games) were excluded from the analysis due to the deliberate and greater risk of falling during these activities compared with normal everyday activities. Participants were categorised by their number of falls, dichotomised as zero to two falls (infrequent falls) or more than two falls (recurrent falls).[26–28] Falls were dichotomised as non-injurious or injurious.

Missing data for outcome and predictor variables were rare (<2% for any measure) with one exception: the Timed Stands Test could not be performed by 13 participants (19%) due to muscle weakness and was thus omitted from the multivariate analysis. Missing data on the Fall Efficacy Scale-International were replaced by the individual mean value if two or less items were missing. If more than two items were missing, then the sum score was not calculated. Other missing data were not imputed. As 82% of participants achieved the top score, the Walking Index for SCI was not used in the multivariate models. Answers to at least 66% of the SMS were required for inclusion in analysis.

Between-group differences were analysed using: the Student's *t*-test for normally distributed continuous data; the Mann-Whitney U test for non-normally distributed continuous and ordinal data; and the Chi-squared test for nominal data. *P*-values ≤0.05 were considered significant. The Spearman's rank correlation coefficient was used to assess correlations. Variables with a correlation coefficient <0.6 were entered into the bivariate logistic regression analysis (Table 2). If several variables assessed similar Q2 constructs, then the one with the lowest *p*-value was entered. The two predictive variables from our retrospective study[7] – 'ability to get up by oneself' and general quality of life – were included.

Table 1
Q4 Characteristics of all participants, also categorised as infrequent falls (zero to two) or recurrent falls (more than two) and categorised as no injurious falls or injurious falls.

Characteristics of participants	All (n = 68)	0 to 2 falls (n = 35)	> 2 falls (n = 33)	*p*-value	No injurious falls (n = 24)	Injurious falls (n = 44)	*p*-value
Gender, n male (%)	45 (66)	25 (71)	20 (61)	0.346	20 (83)	25 (57)	0.027
Age *(yr)*, mean (SD) IQR	55 (15) 45 to 68	56 (16) 43 to 69	55 (13) 46 to 65	0.921	52 (16) 39 to 67	57 (14) 48 to 70	0.154
Education, n (%)							
secondary school or less	23 (34)	13 (37)	10 (30)	0.344	9 (38)	14 (32)	0.875
high school	20 (29)	12 (34)	8 (24)		7 (29)	13 (30)	
college/university	25 (37)	10 (29)	15 (46)		8 (33)	17 (39)	
Working/studying, n (%)	27 (40)	14 (40)	13 (39)	0.959	9 (38)	18 (41)	0.784
Characteristics of spinal cord injury	**All (n = 68)**	**0 to 2 falls (n = 35)**	**> 2 falls (n = 33)**	***p*-value**	**No injurious falls (n = 24)**	**Injurious falls (n = 44)**	***p*-value**
Time since injury *(yr)*, median (range) IQR	12 (1 to 40) 5 to 20	11 (1 to 40) 5 to 19	14 (1 to 43) 4 to 20	0.676	13 (1 to 39) 3 to 20	14 (1 to 43) 5 to 20	0.974
Injury severity, n (%)[a]							
all injury levels AIS A to C	6 (9)	3 (9)	6 (18)	0.299[b]	23 (96)	36 (82)	0.144[b]
all injury levels AIS D	62 (91)	32 (91)	27 (82)		1 (4)	8 (18)	
Lower extremity motor score, median (range) IQR[c]	45 (19 to 50) 40 to 48	45 (19 to 50) 40 to 49	45 (20 to 50) 41 to 47	0.369	46 (19 to 50) 37 to 49	45 (20 to 50) 20 to 50	0.634
Injury mechanism, n (%)							
sport	14 (19)	7 (20)	7 (21)	1.000[b]	4 (17)	10 (23)	0.833[b]
traffic	22 (32)	11 (31)	11 (33)		8 (33)	14 (32)	
fall	28 (41)	15 (43)	13 (39)		10 (42)	18 (41)	
other	4 (6)	2 (6)	2 (6)		2 (8)	2 (5)	

P-values ≤ 0.05 were considered significant.
[a] AIS = American Spinal Injury Association Impairment Scale (A = complete injury; B = sensory incomplete injury; C = Motor incomplete injury, < half of key muscles grade < 3; D = motor incomplete injury, ≥ half of key muscles grade ≥ 3).
[b] Fisher's exact test.
[c] Lower extremity motor score (International Standard for Neurological Classification of Spinal Cord Injury), sum score 0 to 50.

Table 2
Bivariate logistic regression with considered predictors of recurrent (more than two) falls and injurious falls. First category is reference for categorical variables.

Variable	Recurrent falls				Injurious falls			
	β	OR	95% CI	*p*-value	β	OR	95% CI	p-value
Age	–0.00	1.00	0.97 to 1.03	0.850	0.03	1.03	0.99 to 1.06	0.155
Gender *(male/female)*	0.49	1.49	0.59 to 4.47	0.347	1.36	3.80	1.11 to 12.98	0.033
Number of medications *(0 to 2/> 2)*	0.36	1.43	0.52 to 3.96	0.493	0.23	1.26	0.43 to 3.69	0.679
SCI secondary conditions[a]	0.06	1.06	0.97 to 1.17	0.193	0.09	1.09	0.98 to 1.21	0.105
Quality of life[b]	–0.13	0.87	0.71 to 1.07	0.200	–0.17	0.84	0.67 to 1.06	0.142
Lower extremity muscle strength[c]	–0.02	0.98	0.92 to 1.05	0.555	–0.05	0.95	0.83 to 1.08	0.443
Able to get up independently *(Y/N)*	0.60	1.81	0.48 to 6.88	0.382	–1.04	0.35	0.07 to 1.79	0.209
Maximal walking speed *(s)*[d]	0.19	1.20	1.00 to 1.44	0.045	0.20	1.22	0.99 to 1.50	0.057
Risk willingness *(Y/N)*	–0.19	0.82	0.31 to 2.16	0.693	–0.23	0.79	0.29 to 2.16	0.647
Falls in past year *(0 to 2/> 2)*	3.87	48.00	5.87 to 392.80	< 0.001	1.22	3.40	1.17 to 9.88	0.025
Concerns about falling[e]	0.07	1.07	1.00 to 1.14	0.041	0.07	1.07	1.00 to 1.15	0.054
Fear of falling *(Y/N)*	1.20	3.31	1.17 to 9.32	0.024	1.61	5.00	1.71 to 14.60	0.003

SCI = spinal cord injury.
P-values ≤ 0.05 were considered significant.
[a] SCI secondary conditions scale, sum score 0 to 48.
[b] International Spinal Cord Society (ISCoS) general quality of life, score 0 to 10.
[c] Lower limb total motor score according to International Standard Neurological Classification of Spinal Cord Injury, sum score 0 to 50.
[d] 10-m walking test.
[e] Falls Efficacy Scale-International, sum score 16 to 56.

The multivariate logistic regression models were performed with infrequent versus recurrent falls, and non-injurious versus injurious falls as the dependent variables. Four variables were entered into the model for recurrent falls based on former research findings, clinically relevance, and bivariate regression correlations with $p \leq 0.20$. The analysis was carried out using backwards enter mode removing the variable with the highest *p*-value until the final model only contained significant variables ($p \leq 0.05$). The significant predictors from this model were entered into the model of injurious falls and analysed using backwards enter mode. Age and gender were kept in the final model, despite exceeding the recommended 10 events per variable[29] and not being significant, because they are known risk factors and seemed to provide some explanatory value, even in this small study.[30,31] Colinearity between variables was investigated in the final models. The results are presented as odds ratios (OR) with 95% confidence intervals (CI). Measures of predictive accuracy were presented with positive and negative predictive values with 95% CI, model fits with Hosmer-Lemeshow tests of goodness-of-fit statistics, and area under Receiver Operating Characteristics curves (AUC). Statistical analyses were performed using two types of commercial statistical software.[b,c]

Results

Flow of participants

Four participants dropped out during the follow-up period, and one had insufficient SMS responses. Thus, 68 were included in the analysis (Figure 1). Mean percentage of SMS answers, including telephone follow-up when failing to answer the reminder SMS, was 98%. One participant was mainly contacted by telephone (aged >80 years old) and one by e-mail.

Falls

During the 1-year registration period, 272 falls were reported, with sports-related falls excluded. Twelve participants (18%) did not fall, 17 (25%) fell once, six (9%) twice and 33 (48%) three times or more. The median number of falls was two (IQR one to six, maximum 23). The distribution of falls according to gender and age categories is shown in Figures 2 and 3. Peak prevalence for falls was in the middle age category (46 to 60 years). There were no significant differences between the infrequent and recurrent fallers with regards to gender, age, level of education, employment status, or SCI characteristics (Table 1).

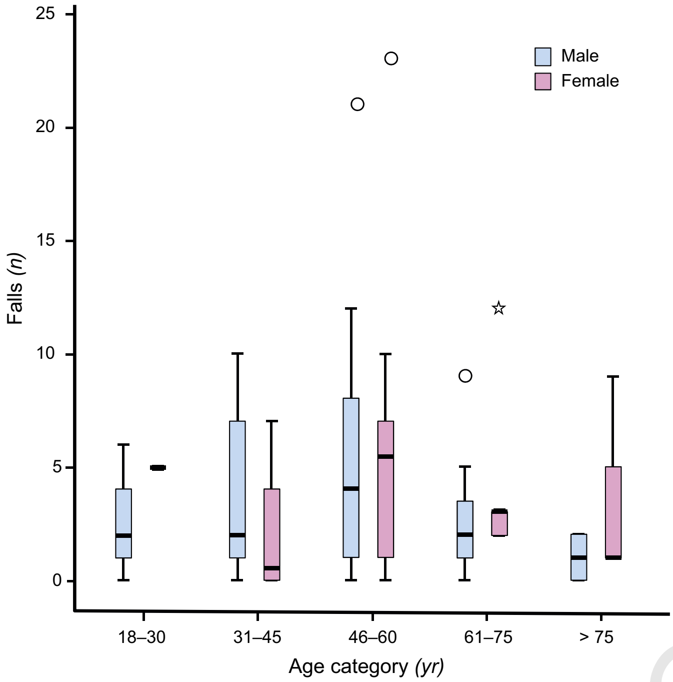

Figure 2. Distribution of falls according to age categories and gender.

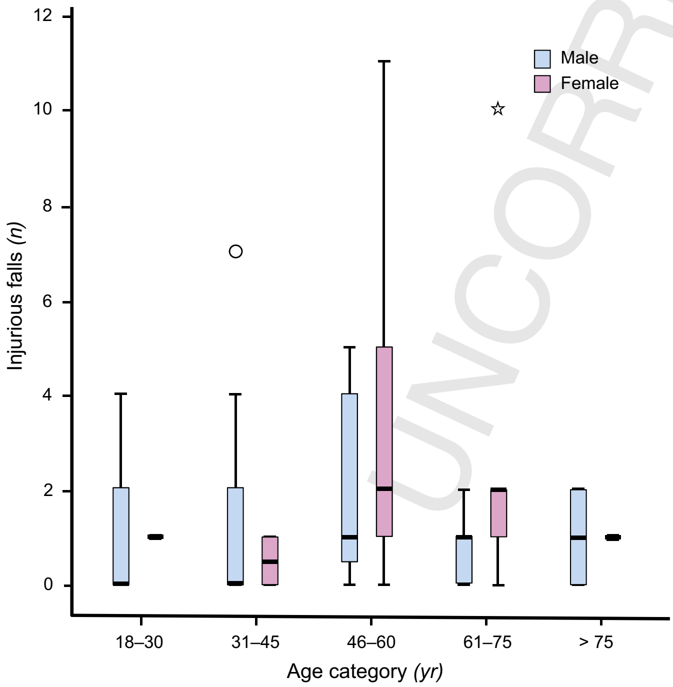

Figure 3. Distribution of injurious falls according to age categories and gender.

A total of 46% of the falls occurred indoors. Most falls occurred during the day (60% between 09:00 and 18:00). Getting in and out of a chair accounted for most indoor falls (20%). Walking on uneven or slippery surfaces accounted for most outdoor falls (31 and 21%, respectively).

There was no significant correlation between balance performance measured with Berg Balance Scale and recurrent falls (r_s = –0.219, p = 0.076), although there was a negative but low correlation between number of falls and the Berg Balance Scale (r_s = –0.28, p = 0.024). There were no significant differences between infrequent fallers and recurrent fallers in muscle strength measured by Timed Stands Test (r_s = 0.12, p = 0.387, n = 55) and lower extremity motor score in the International Standards for Neurological Classification of Spinal Cord Injury (r_s = –0.11, p = 0.373).

The odds of recurrent falls were at least 8.6 times higher (lower CI) for participants with a history of recurrent falls in the previous year in comparison to those without such a history. The odds of recurrent falls were 6.1 times higher for participants who were afraid of falling compared with those unafraid of falling. With increasing time taken to walk 10 m, the odds of recurrent falls increased by 31% per second (Table 3). The wide CI and difficulties with estimating the true OR for recurrent falls in the previous year, as displayed in Table 3, was caused by the small sample size. The final model explained 44 to 62% of the variation in the dependent variable, and 87% of all cases were correctly classified as recurrent fallers. The positive predictive value was 89% (95% CI 73 to 97), and the negative predictive value was 85% (95% CI 69 to 94).

Injurious falls

Forty-four participants (65%) reported at least one injurious fall, and the median number was one (IQR zero to two); women reported significantly more falls than men (Table 1). Injurious falls were positively correlated with number of reported falls (r_s = 0.74, $p \leq$ 0.001). Of the 272 reported falls, 111 (41%) were injurious, and 93 of these resulted in minor injuries. Nine participants (13%) sustained a moderate injury. Three participants (4%), all women aged >55 years, sustained serious injuries: one had two fractures (rib and thumb) in two outdoor falls because of slippery walking conditions, one stumbled when walking outside resulting in a hand fracture, and one fainted indoors due to illness and fell from a sitting position, which resulted in a cervical vertebral fissure. Injurious falls occurred equally indoors and outdoors. Although not reaching significance (p = 0.054), there was a trend towards difference, in that more moderate and serious injuries occurred indoors (13 versus 6), and more falls with minor injuries occurred outdoors (135 versus 113).

The odds of injurious falls were 4.2 times higher for individuals with history of recurrent falls in the previous year in comparison to those without such a history. The odds of injurious falls were 4.3 times higher for individuals afraid of falling compared with those unafraid of falling (Table 3). The final model explained 25 to 34% of the variation in the dependent variable; 65% of all cases were correctly classified. The positive predictive value was 84% (95% CI, 69 to 93), and the negative predictive value was 64 (95% CI 44 to 82).

Performance of predictive models

The Hosmer-Lemeshow test was not statistically significant for any of the prediction models (0.133 for recurrent falls and 0.583 for injurious falls). The AUC for the models were 0.90 (95% CI 0.81 to 0.96) for recurrent falls and 0.80 (95% CI 0.68 to 0.88) for injurious falls.

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Table 3
Full and final multivariate logistic regression models of predictors of recurrent (more than two) falls and injurious falls. First category is reference for categorical variables. No decimals indicated if OR ≥ 10.

Variable	Full model				Final model			
	β	OR	95% CI	*p*-value	β	OR	95% CI	*p*-value
Recurrent falls (dependent variable)								
Quality of life[a]	0.21	1.24	0.88 to 1.74	0.218				
Timed 10-m walking, max speed *(s)*[b]	0.22	1.25	0.92 to 1.25	0.153	0.27	1.31	1.02 to 1.68	0.034
Falls in past year *(0 to 2/>2)*	5.19	179	10 to 3189	≤ 0.001	4.71	111	8.58 to 1425	≤ 0.001
Fear of falling *(Y/N)*	1.84	6.28	1.24 to 32	0.026	1.81	6.09	1.43 to 26	0.015
Concerns about falling[c]	0.05	1.05	0.92 to 1.20	0.461				
Injurious falls (dependent variable)								
Age *(yr)*	0.03	1.03	0.98 to 1.07	0.218	0.04	1.04	0.99 to 1.08	0.093
Gender *(male/female)*	0.87	2.39	0.57 to 10	0.233	1.00	2.71	0.68 to 11	0.158
Timed 10-m walking, max speed *(s)*[b]	0.13	1.13	0.90 to 1.43	0.293				
Falls in past year *(0 to 2/>2)*	1.37	3.95	1.13 to 14	0.032	1.43	4.16	1.21 to 14	0.023
Fear of falling *(Y/N)*	1.46	4.29	1.26 to 15	0.020	1.45	4.25	1.26 to 14	0.018

Overall model fit (Hosmer-Lemeshow test):.
Recurrent falls; full model; Chi-squared = 8.10, df = 8, n = 67, p = 0.423 and final model; Chi-squared = 12.29, df = 8, n = 67, p = 0.139. Cox & Snell R^2 = 0.50, Nagelkerke R^2 = 0.66.
Injurious falls; full model Chi-squared = 7.46 df = 8, n = 67, p = 0.488 and final model; Chi-squared = 12.432 df = 8, n = 68, p = 0.133. Cox & Snell R^2 = 0.26, Nagelkerke R^2 = 0.36.
SCI = spinal cord injury.
[a] SCI secondary conditions scale, sum score 0 to 48.
[b] 10-m walking test.

Discussion

This study explored the incidence of falls and fall-related injuries in 68 ambulatory individuals with chronic SCI. To the best of our knowledge, this is the first study to develop multivariate prediction models for recurrent falls and injurious falls in a cohort of ambulatory individuals with SCI who were followed for 1 year. Falls and injurious falls were common: 82% fell at least once, 48% fell three times or more, and 65% had at least one injurious fall during the 1-year follow-up period. In total, 13% of the participants reported a moderate injury and 4% reported a serious injury. A history of recurrent falls (more than two) and being afraid of falling were significant predictors both for recurrent falls and injurious falls. Furthermore, longer time taken to walk 10 m as fast as possible was a risk factor for recurrent falls.

The vast majority fell at least once, which is in accordance with Brotherton and colleagues.[6] Over 50% of participants fell more than three times, which is more than in able-bodied individuals.[30] Middle-aged individuals had the most falls, which is consistent with findings of Matsuda and colleagues.[18] Half of the falls occurred indoors, which is contrary to able-bodied individuals who mostly fall outdoors,[30,32] but similar to findings in individuals with SCI,[2] and in adults aged >60 years.[14] Walking on uneven or slippery surfaces accounted for most outdoor falls. The exposure to slippery walking conditions during wintertime may add to fall incidence in countries with such seasonal conditions, as shown in the elderly.[33]

This study found that a history of falls was a strong predictor for future falls in ambulatory individuals, as in wheelchair users with SCI[34] and in other populations.[35,36] Both intrinsic factors (eg, underlying neurological and musculoskeletal problems)[14] and behaviour that increases fall risk[36] may explain the findings.

Similar to Phonthee and colleagues,[3] it was found that fear of falling was a risk factor for recurrent falls. It is unclear whether fear causes falls and fall-related experience cause fear, or whether fear is caused by underlying factors that enhance fall risk, such as impaired balance control, muscle weakness or impaired sensation that is typical for this population. In a population-based study in the elderly, Friedman and colleagues[37] found a spiralling effect between increasing falls, fear of falling and functional decline in the elderly. This might also apply to the SCI population. Although fear of falling was assessed with a single-item question, it remained significant through the multivariate analysis, indicating that this question is important in identifying recurrent fallers among ambulatory individuals with SCI.

Although a somewhat weak predictor, participants who took more time to walk 10 m as fast as possible tended to fall more. When regarding this as a proxy for lower levels of physical functioning, it is consistent with a later study by Phonthee and colleagues,[2] but unlike findings in other studies.[3–5,15,18] Different ways of measuring physical functioning and sample differences may explain this discrepancy. On the other hand, a suggested non-linear relationship between physical functioning and falls (where individuals with either low or high functioning have increased risk of falling) may explain these contradictory findings.[19]

Falling does not necessarily represent a problem, unless it entails negative subsequent consequences. The proportion of individuals that experienced moderate and serious injuries was similar to findings in other studies.[3–5,12] Women reported more injurious falls than men, which has also been reported in healthy adults.[30] Moreover, all fractures occurred in postmenopausal women. This has been shown by other groups.[31] Although gender was significant in the bivariate analysis, it was not a significant predictor in the final model of injurious falls. This may have been due to the small sample size.

Strengths of our study include few dropouts, a low percentage of missing data, high answering rate, the long follow-up period, and clinically assessed independent variables. Also, the short recall period of 2 weeks between each SMS and rigorous follow-up of fall reports presumably minimised recall bias. Thus, this sample was regarded as representative of a 1-year cohort of ambulatory individuals with chronic, traumatic SCI at the two rehabilitation centres. The few dropouts and the high answering rate may indicate that participation was perceived as meaningful.

The main limitation is that the study was slightly underpowered for multivariate analysis. This resulted in wide confidence intervals for history of recurrent falls and difficulties in estimating the true odds ratio. However, the lower confidence limit still indicated higher odds ratios for variables reaching statistical significance. Moreover, there is a risk of selection bias based on participation in regular follow-up systems. Nevertheless, the well-functioning follow-up system of individuals with SCI in Norway and Sweden allows good case detection in the catchment areas.

The high fall incidence in ambulatory individuals with SCI is alarming. The mean age at SCI is now higher than previously, and more individuals remain ambulatory after SCI. Clearly, prevention measures should be initiated during rehabilitation and life-long follow-up; they should target those persons at risk of injurious falls. These prediction models using fall history, fear of falling and walking speed could predict recurrent falls and injurious falls.

Further studies with larger cohorts are needed to confirm these findings.

Footnotes: [a] SMS-Track ApS, Esbjerg, Denmark. [b] IBM-SPSS Statistics version 22.0, SPSS Inc., Chicago, USA. [c] MedCalc Statistical Software version 16.4.3, MedCalc Software bvba, Ostend, Belgium.

eAddenda: Appendix 1 can be found online at doi:10.1016/j.jphys.2016.11.010.

Ethics approval: The Regional Ethics Committee for Medical Research Ethics in South East Norway (Dnr: 2012/531) and the local ethics committee in Stockholm, Sweden (Dnr: 2012/830-31/2, 2013/391-32, 2014/364-32) approved this study. All participants gave written informed consent before data collection began.

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