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ORIGINAL REPORT

HIGH INCIDENCE OF FALLS AND FALL-RELATED INJURIES IN WHEELCHAIR USERS WITH SPINAL CORD INJURY: A PROSPECTIVE STUDY OF RISK INDICATORS

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Objective: **To identify risk indicators for, and incidence of, recurrent falls and fall-related injuries in wheelchair users with traumatic spinal cord injury.**
Design: **Prospective multi-centre study.**
Subjects: **One hundred and forty-nine wheelchair users with spinal cord injury attending follow-up in Sweden and Norway.**
Methods: **Inclusion criteria: wheelchair users ≥18 years old with traumatic spinal cord injury ≥1 year post-injury. Exclusion criteria: individuals with motor complete injuries above C5. Falls were prospectively reported by text message every second week for one year and were followed-up by telephone interviews. Outcomes were: fall incidence, risk indicators for recurrent (>2) falls and fall-related injuries. Independent variables were: demographic data, quality of life, risk willingness, functional independence, and exercise habits.**
Results: **Of the total sample ($n=149$), 96 (64%) participants fell, 45 (32%) fell recurrently, 50 (34%) were injured, and 7 (5%) severely injured. Multivariate logistic regression analysis showed that reporting recurrent falls the previous year increased the odds ratio (OR) of recurrent falls (OR 10.2, $p<0.001$). Higher quality of life reduced the OR of fall-related injuries (OR 0.86, $p=0.037$).**
Conclusion: **Previous recurrent falls was a strong predictor of future falls. The incidence of falls, recurrent falls and fall-related injuries was high. Hence, prevention of falls and fall-related injuries is important.**

Key words: accidental fall; rehabilitation; risk factors; spinal cord injury; wheelchair; secondary complications.

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Although falls is an increasing field of interest in spinal cord injury (SCI) research (1–7), falls and related injuries have, to our knowledge, not yet been thoroughly studied among wheelchair users. Since the incidence of both falls (5) and recurrent falls have been reported as high (1, 4), falls should be considered as common in the SCI population. It is known from research on elderly ambulatory individuals (8–10) that a history of repeated falls increases both the risk of future falls and of related injuries. Furthermore, recurrent falls have been reported as easier to predict than single falls and as being more closely associated with neurological and musculoskeletal problems (10).

Wheelchair users with SCI who fall are at great risk of fractures, since they have an increased prevalence of osteoporosis (11). Fall-related injuries might lead to increased dependence in daily activities, thus increasing the cost for society as well as the suffering for the individual. Moreover, such injuries might lead to secondary complications, such as pressure sores, a well-known problem during a lifetime with SCI (12). Hence, this is a vulnerable population in which fall-related injuries may have detrimental effects.

In order to reduce the risk of falls and fall-related injuries, it is important to determine the risk indicators of both falls and related injuries. Falls in wheelchair users with SCI have been investigated specifically in 1 study (5) and in a few studies with mixed samples (1–3, 4, 6, 7, 13–15). Paraplegia (3) or higher level of functional independence (3, 5, 15), male sex (3, 15), younger age (15), pain (5), higher alcohol consumption (16), history of previous fall (5, 15), fewer years since SCI (5), and shorter wheelbase of wheelchair (5) have been shown to be associated with falls. Hence, this wide range of factors indicates that falls in wheelchair users with SCI is a complex issue, and that consensus on risk indicators of falls in this population is not yet established and calls for further investigation. Concerning fall-related injuries, the knowledge is even more limited and the incidence has been reported to range from 10% to 14% per year (5, 6), to 10% per 6 months (7). In a mixed sample of wheelchair users (including 24% with SCI), 47% reported fall-related injuries since the onset of their wheelchair use (3). Thus, there is a gap in our knowledge about the risk indicators for fall-related injuries in wheelchair users with SCI.

The aim of this study was therefore to identify the incidence of falls and recurrent falls (>2 falls), to

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describe the circumstances around the falls, and risk indicators for recurrent falls. The aim was further to identify the incidence and severity of fall-related injuries, and to describe risk indicators for fall-related injuries in wheelchair users with chronic traumatic SCI.

METHODS

This observational prospective study on wheelchair users with SCI is part of the SCI Prevention of Falls (SCIP FALLS) study. Results from a larger sample, consisting of both wheelchair users and ambulatory individuals, on retrospectively reported falls have been reported previously (15). A fall was defined as "an unexpected event in which the participants come to rest on the ground, floor, or lower level" according to the Prevention of Falls Network Earth (ProFaNe) (17). The study was approved by the Regional Ethics Committee for Medical Research Ethics in South East Norway in 2012 (Dnr: 2012/531) and by the Regional Ethical Review Board in Stockholm, Sweden (Dnr: 2012/830-31/2, 2013/391-32, 2014/364-32). All participants gave their written informed consent after receiving oral and written information.

Participants

A consecutive sample of 151 individuals with complete and incomplete traumatic SCI were recruited from Sunnaas Rehabilitation Hospital, Oslo, Norway and Rehab Station Stockholm/Spinalis, Stockholm, Sweden in connection with regular follow-up visits between February 2013 and April 2014. Participant characteristics are presented in Table I.

The inclusion criteria were: individuals with traumatic SCI using a wheelchair for at least 75% of their mobility needs (18), at least one year post-injury, ≥18 years of age, ability to cooperate, and to understand Norwegian or Swedish in speech and writing. Exclusion criteria were: motor complete injuries above C5 level (American Spinal Cord Injury Impairment Scale (AIS) A and B), injuries below L5 level and injuries classified as AIS E (normal sensory and motor functions) according to International Standard Neurological Classification of Spinal Cord

Table I. Participant characteristics for total sample and displayed as low frequent (0–2) vs recurrent (> 2) fallers and as not injured vs injured

		Falls			Injuries		
	Total sample	Low frequent falls (0–2)	Recurrent falls (>2)		Not injured	Injured	
Characteristics	(*n* = 149)	(*n* = 104, 70%)	(*n* = 45, 30%)	*p*-value	(*n* = 95, 64%)	(*n* = 54, 36%)	*p*-value
Sex, *n* (%)							
Male	123 (83)	85 (82)	38 (84)	0.689	79 (83)	44 (81.5)	0.795
Female	26 (17)	19 (18)	7 (16)		16 (17)	10 (18.5)	
Age, years (SD)	47 (14)	48.6 (14.4)	43.9 (12.4)	0.064	47.2 (13.5)	47.1 (14.9)	0.958
Median (IQR)	47 (19)	48.0 (20.5)	46.0 (18.5)		46 (18)	48.5 (19.2)	
Min–max	1–52	18–79	19–71		18–77	19–79	
Marital status *n* (%)							
Married/living with partner	81 (54)	54 (52)	27 (60)	0.363	41 (43)	27 (50)	0.420
Without	68 (46)	50 (48)	18 (40)		54 (57)	27 (50)	
Education, *n*[a] (%)							
Secondary school or less	45 (30)	33 (32)	12 (27)	0.312	24 (25)	21 (39)	0.234
High school	46 (31)	35 (34)	11 (24)		31 (33)	15 (28)	
College/university	57 (38)	36 (35)	21 (47)		39 (41)	18 (33)	
Work, *n* (%)							
Not working/studying	75 (50)	61 (59)	14 (31)	0.002	46 (48)	29 (54)	0.535
Working/studying	74 (50)	43 (41)	31 (69)		49 (52)	25 (46)	
SCI characteristics							
Duration of injury, mean (SD)	18.6 (12.8)	19.0 (13.1)	17.5 (12.0)	0.519	18.6 (12.7)	18.5 (13.1)	0.951
Median (IQR)	16 (20)	17.5 (21)	15.0 (14.5)		16 (20)	16.5 (19.5)	
Min–max	1–56	1–56	2–49		1–52	2–56	
Injury level, *n* (%)							
Cervical	70 (47)	50 (48)	20 (44)	0.271	43 (45)	27 (50)	0.587
Thoracic 1–6	32 (22)	18 (17)	14 (31)		20 (21)	12 (22)	
Thoracic 7–12	39 (26)	30 (29)	9 (20)		28 (30)	11 (20)	
Lumbar	8 (5)	6 (6)	2 (4)		4 (4)	4 (7)	
Completeness, *n* (%)							
AIS A	96 (64)	65 (62.5)	31 (69)	0.557	61 (64)	35 (65)	0.979
AIS B	30 (20)	20 (19)	10 (22)		19 (20)	11 (20)	
AIS C	16 (11)	13 (2.5)	3 (7)		10 (11)	6 (11)	
AIS D	7 (5)	6 (6)	1 (2)		5 (5)	2 (4)	
Injury mechanism, *n* (%)							
Sport	37 (25)	26 (25)	11 (24)	0.137[b]	27 (28)	10 (19)	0.502[b]
Violence	2 (1)	2 (2)	0 (0)		1 (1)	1 (2)	
Traffic	67 (45)	41 (40)	26 (58)		40 (42)	27 (28)	
Fall	37 (25)	31 (30)	6 (13)		22 (23)	15 (28)	
Other	6 (4)	4 (4)	2 (4)		5 (5)	1 (2)	

To detect differences between groups' Student's *t*-test was used for normally distributed continuous data, and χ^2 for nominal data. *p*-values ≤ 0.05 were considered significant. [a]Educational data missing for one participant. [b]Fisher's exact test.
AIS: American Spinal Injury Association impairment scale; SD: standard deviation; IQR: interquartile range.

Injury (19). With a total of 149 individuals in the sample and 30% experiencing recurrent falls, 5 independent variables could be included in the model according to the rule of thumb (20).

Data collection procedure

Study variables were chosen with a broad perspective, based on previous findings from studies on falls in the SCI population (3, 5, 15, 16). Data collection was performed in Norway and Sweden by either of the authors (VJ and EBF), both of whom have more than 15 years of expertise in SCI rehabilitation. The baseline data collection comprised 3 parts: a structured interview, clinical assessments and self-administered questionnaires.

Structured interview included: socio-demographic and background factors (working/studying), fall history (self-reported falls the previous year, self-reported fall-related injuries the previous year), fear of falling no/yes (21), degree of interference of pain and spasticity on activity and independence (22), regular exercise (defined as exercising for at least 30 min at least 1–2 times/week) or not, risk willingness ("liking to take chances no/yes") (23), and satisfaction with general quality of life (overall wellbeing) (24). Risky alcohol consumption was defined as drinking more than 5 units of alcohol at least once per month for men (4 units for women), according to the limits by the Swedish National Guidelines (25).

Clinical assessments were: SCI level and classification according to international standards (20), body mass index (BMI) and functional independence Spinal Cord Independence Measure (SCIM) III mobility sum score (26).

Self-administrated questionnaires: fall-related psychological aspects (SCI Falls Concern Scale [FCS]) (18, 27), symptoms of depression and anxiety defined as >7 on the Hospital Anxiety and Depression Scale (HADS) (28) subscore. HADS assesses how the subject felt during the last week. Fatigue was defined as a score ≥ 5 on the Fatigue Severity Scale (FSS) (9), a scale assessing the effect of fatigue in everyday life. The data collection was performed in the same order for all participants, allowing for brief pauses if needed, and was mainly carried out in a single 2–2.5 h session.

Prospectively reported falls were registered via text message, "Have you fallen the last 2 weeks? Please answer no or yes" (©SMS-Track ApS, Esbjerg, Denmark), delivered every second week for 12 months, resulting in 26 text messages per person. A reminder was sent after 2 days if a participant did not answer the text message. A telephone follow-up was performed if there was no response to the reminder. Participants who did not manage to continue with the text messages throughout the entire registration period, were followed-up by telephone or e-mail. Participants were included in the analysis if they answered at least 2/3 of the text messages.

When a fall was reported the circumstances leading up to the fall and eventual related injuries were registered in a semi-structured telephone interview. Fall location, weekday, time and self-reported reasons for the falls were registered and categorized. Since participation in sports is voluntary and often associated with a higher risk of falls, falls that were directly related to sports were registered, but not included in further analysis. Fall-related injuries were classified as: minor (such as bruises, scratches or pain less than 3 days), moderate (strains or sprains) and severe (such as fractures) (30). In addition, after 4, 8 and 12 months, semi-structured telephone interviews were performed to ensure that the participants were well aware of the definition of falls and to increase adherence.

Statistical analysis

All statistical analyses were performed using IBM-SPSS Statistics, versions 22.0 (SPSS Inc., Chicago, IL, USA). Non-parametric statistics were used for not normally distributed continuous variables. Number of prospectively reported falls was regarded as a dependent variable of the study, dichotomized as 0–2 (low frequent) or >2 (recurrent) (31, 32). Furthermore, fall-related injuries were used as a dependent variable, and dichotomized as no injury vs any injury.

Missing data on self-reported questionnaires (SCI-FCS, FSS or HADS) were replaced by the individual mean value if ≤ 2 items were missing, and if more than 2 items were missing the sum score was not calculated as recommended by ProFaNe. Other missing data were not imputed.

Student's *t*-test was used to detect differences between groups for normally distributed continuous data. Mann-Whitney *U* test was used to detect differences between groups for not normally distributed continuous data and ordinal data, and χ^2 for nominal data. Fisher's exact test was used for analysing differences between groups with few persons (<5).

Independent variables were selected based on previous research (5). Spearman's rank correlation coefficient (r_s) was used to check for correlations between variables. In order to avoid collinearity in the multivariate regression models and to reduce the number of variables, variables with correlation less than 0.4 were selected and entered in the bivariate regression analysis. For variables assessing similar constructs, such as different measures of physical function, only one(with the lowest *p*-value) was used in the multivariate model even if the correlation was less than 0.4. In order to reduce the number of variables in the multivariate models, relationships significant at $p \leq 0.03$ for recurrent falls and $p \leq 0.3$ for fall-related injuries were eligible for entry into the initial multivariate regression models. Thereafter, multivariate logistic regression models were performed with low frequent vs recurrent falls and no fall injuries vs any fall injury as dependent variables. Odds ratios (OR) and 95% confidence intervals (95% CI) were calculated for factors associated with recurrent falls and fall-related injuries. The multivariate regression models were analysed using a backwards enter mode with final predictor variables assessed at $p \leq 0.05$. Age and sex were considered as possible confounders and, therefore included in all models. Model fit for the final model was examined with Hosmer and Lemeshow tests of goodness-of-fit statistics.

RESULTS

Participant flow

Of 270 eligible persons in the SCIP Falls study, 37 declined to participate, 9 were excluded due to illness, and 73 were ambulatory. The remaining 151 wheelchair users were included in the study. Two participants withdrew their participation after 4.5 and 8 months, respectively, hence 149 were included in the analysis.

Text messages

The mean answering rate of the text messages was 98%, (median 100%, min–max 73–100%). All par-

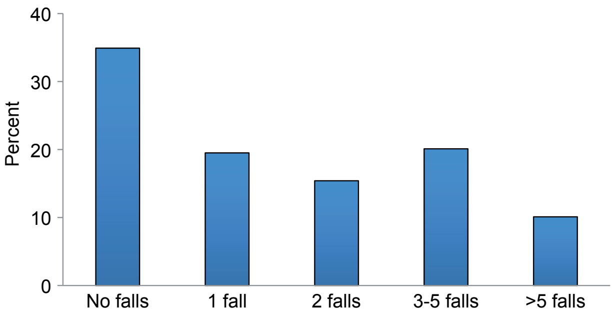

Fig. 1. Proportion of reported falls during 12 months.

ticipants reached the preset criteria of answering at least 2/3 of the text messages, and thus 149 individuals were included in the analysis. Due to travels abroad or technical problems 5 participants were partly followed-up by telephone and e-mail.

Descriptive data on falls

A total of 448 falls was registered, of these 142 were classified as directly related to sport activities (132 sit-ski, 5 ice-hockey, 2 wheelchair rugby, 2 ball games, and 1 sailing) and excluded from further analysis, thereby 306 falls remained for analysis. Ninety-six individuals reported falling at least once (64%), and 45 (32%) reported recurrent (>2) falls (Fig. 1). The mean number of falls during the 1-year period was 2.1 (SD 2.7) and median 1 (min–max 0–14). Most falls (65%) occurred indoors and 47% occurred between 09.00 h and 18.00 h. The most common situations for falls were wheelchair transfers (105 falls; 55 to bed/sofa/other chair, 27 to car, and 23 to toilet/commode) and pushing wheelchair 74 falls (on flatground 18, on uneven surface 37, over gutters or curbs 24).

Regression analysis for recurrent falls

In the bivariate analysis (Table II), those who reported recurrent falls the previous year, those who were working or studying, and those who had a higher level of functional independence (SCIM-III), had significantly ($p<0.05$) higher odds ratio of reporting recurrent falls the following year. The initial multivariate model included 5 variables (age, sex, previously reported recurrent falls, functional independence and employment) and the final included 3 (age, sex and previously reported recurrent falls) (Table III). Participants who reported recurrent falls the previous year had 10.2 times higher odds ratio (OR) of recurrent falls the following year ($p<0.001$), than those not reporting recurrent falls (Table III). Sex and age were included in the model; however, they did not influence the estimate by more than 10%.

Descriptive data on fall-related injuries

A total of 70 fall-related injuries was registered, of these 47 (67%) were minor (mostly bruises, scratches or pain less than 3 days), 16 (23%) were moderate (mostly strains or sprains) and 7 (10%) severe (6 femoral or tibiae fractures and 1 concussion). Of all 149 participants 50 (34%) reported at least 1 fall-related injury, (37 (25%) reported 1, 7 (5%) reported 2, 5 (3%) reported 3 and 1 (1%) reported 4 fall-related injuries). Hence, 70 (23%) of the 308 falls were injurious, and 50 (52%) of the 96 individuals who fell where injured to some extent. Seventeen participants (18%), of those who fell, reported seeking medical attention after falls, (1 participant did this twice). Of those 6 participants who had fractures, 4 were injured during transfers from wheelchair to bed/commode/toilet, 1 because the

Table II. Bivariate logistic regression analysis of factors associated with recurrent (> 2) falls and fall-related injuries (no vs all injuries). First category is reference for categorical variables unless otherwise stated

	Recurrent falls (0–2 or > 2)				Fall-related injuries (no injury vs any injuries)			
Variable	*p*-value	β	OR	95% CI	*p*-value	β	OR	95% CI
Age	0.066	−0.02	0.98	0.95–1.00	0.612	−0.01	0.99	0.97–1.02
Sex (ref woman)	0.689	0.19	1.21	0.47–3.13	0.741	0.15	1.17	0.47–2.91
Working or studying (no/yes)	**0.003**	1.15	3.14	1.45–6.60	0.525	−0.22	0.80	0.41–1.59
Body mass index	0.200	−0.05	0.95	0.87–1.03	0.890	0.01	1.01	0.93–1.08
>3 medications (no/yes)	0.075	−0.87	0.42	0.16– 1.10	0.866	−0.07	0.93	0.41–2.11
Alcohol consumption > 4/5units > once/month (no/yes)	0.452	0.30	1.35	0.61–2.98	0.570	−0.23	0.79	0.35–1.77
Fall previous year 0–2/> 2	**< 0.001**	2.30	9.98	4.36–22.85	0.440	0.27	1.31	0.66–2.07
Fall injury previous year (no/yes)	0.079	0.64	1.89	0.93–3.85	0.226	0.42	1.53	0.77–3.30
Fear of falling (no/yes)	0.091	−0.66	0.52	0.24–1.11	0.845	0.07	1.07	0.53–2.17
Falls concern SCI-FCS	0.343	−0.02	0.98	0.94–1.02	0.686	0.01	1.01	0.97–1.05
Like to take chances (no/yes)	0.279	0.40	1.49	0.72–3.09	0.779	0.10	1.11	0.55–2.23
SCIM III mobility score	**0.020**	0.12	1.12	1.02–1.24	0.612	0.02	1.02	0.95–1.10
Regular exercise (no/yes)	0.952	−0.02	0.98	0.48–2.00	0.711	−0.13	0.88	0.44–1.76
General quality of life[a]	0.574	0.04	1.04	0.90–1.22	0.065	−0.14	0.87	0.76–1.01
Depressive symtoms HADS[b] (no/yes)	0.370	0.60	0.55	0.15–2.04	0.262	0.62	1.85	0.63–5.44
Fatigue FSS[c] (no/yes)	0.858	0.09	1.09	0.41–2.90	0.431	0.37	1.45	0.57–3.67

[a]International Spinal Cord Injury Quality of Life Basic Data Set.[b]Hospital Anxiety and Depression Scale. Depression sum score > 7. [c]Fatigue Severity Scale ≥ 5. 95% CI: 95% confidence interval; OR: odds ratio. SCIM III: Spinal Cord Independence Measure III; SCI-FCS: Spinal Cord Injury Falls Concern Scale. *p*-values < 0.05 in bold.

Table III. Initial and final multivariate logistic regression model consisting of age, sex and significant factors associated with recurrent (> 2) falls. First category is reference for categorical variables unless otherwise stated

	Initial model				Final model			
Variable	*p*	β	OR	95% CI	*p*	β	OR	95% CI
Age	0.989	0.00	1.00	0.97–1.03	0.641	−0.01	0.99	0.96–1.02
Sex (ref woman)	0.608	−0.31	0.74	0.23–2.37	0.455	−0.43	0.65	0.21–2.00
Working or studying (no/yes)	0.081	0.78	2.18	0.91–5.21				
Falls previous year (0–2/> 2)	< 0.001	2.16	8.64	3.51–21.29	< 0.001	2.33	10.27	4.27–24.74
SCIM III mobility score	0.448	0.04	1.04	0.94–1.16				

Overall model fit (Hosmer–Lemeshow test): $\chi^2 = 6.272$, df = 8, $n = 149$, $p = 0.617$.
SCIM III: Spinal Cord Injury Independence Measure III.

new lightweight wheelchair slid away. Two fell forward while driving the wheelchair. Of these 6 participants, 2 fell during sickness (fever or poor general health) and 1 after a change in medication causing decreased spasticity. Also, 1 fell backwards while pushing the wheelchair backwards and had concussion.

Regression analysis on fall-related injuries

In the bivariate regression analysis (Table II), none of the variables had a *p*-value < 0.05. The initial multivariate model included 5 variables (age, sex, general quality of life, fall injury previous year and depressive symptoms), and the final, included 3 (age, sex, general quality of life) (Table IV). The final model showed that, for each units' increase in general quality of life (e.g. higher general quality of life), the OR of having a fall-related injury the following year decreased by14.3 percentage points (OR 0.86, $p = 0.037$).

DISCUSSION

This prospective multi-centre study reported higher fall rates than previously reported in a sample of wheelchair users with SCI ($n = 149$) (1–5). During one year, almost two-thirds (64%) of the participants fell and approximately one-third (32%) fell recurrently. In total, 306 falls and 70 fall-related injuries were registered; of these 7 were serious injuries. After analysing a broad range of variables in multivariate regression models, previous recurrent falls was the only significant risk indicator for recurrent falls, while increasing general quality of life decreased the odds ratio of fall-related injuries.

In comparison, Nelson et al. (5) showed that approximately one-third (31%) fell, and one-sixth (17%) fell more than once in a 1-year prospective study. The samples seem fairly similar with respect to age distribution, although Nelson et al.'s sample had a longer time since SCI, very few women, and lower work rate. Thereby one explanation for the difference in fall incidence may be that fewer years since SCI were shown to increase the risk of falls in their study and that those who were working had a higher risk in the present study. Amatachaya et al. (1) showed a more similar fall rate, since 33% fell during a 6-month prospective study ($n = 21$); however, environmental factors, technical aids and adaptations differ between Thailand and the Nordic countries, possibly affecting the results. Similar fall rate was also reported by Matsuda et al. (4), with 31% falling in 6 months (retrospective study). In spite of longer reporting periods, other retrospective studies also reported lower incidence; 49% falling in the previous 3 years (2) and 57% falling since the start of their wheelchair use (3). The different fall rates might be due to differences in study design and samples. The prospective design with follow-up every second week during a year in the present study reduce the risk of recall bias, which might explain a higher incidence compared with retrospective studies and studies with monthly fall registration. Moreover, the present study had a high response rate and a low rate of drop-outs, which may further accentuate this tendency. However, different reporting periods complicates comparison of the results; the fall incidence during 6 months may not be equivalent to half of the 12-month incidence.

Table IV. Initial and final multivariate logistic regression model consisting of age, sex and factors associated with no fall related injury vs fall related injuries. First category is reference for categorical variables unless otherwise stated

	Initial model				Final model			
Variable	*p*-value	β	OR	95% CI	*p*-value	β	OR	95% CI
Age	0.956	−0.00	1.00	0.98–1.02	0.943	0.00	1.00	0.98–1.03
Sex (ref woman)	0.759	−0.14	0.87	0.36–2.12	0.729	−0.16	0.86	0.35–2.07
Fall injury previous year (no/yes)	0.138	−0.53	0.59	0.30–1.19				
Quality of life[a]	0.074	−0.15	0.86	0.73–1.02	**0.037**	−0.15	0.86	0.74–1.00
Depressive symptoms[b] (no/yes)	0.965	0.03	1.03	0.30–3.48				

[a]International Spinal Cord Injury Quality of Life Basic Data Set. [b]Hospital Anxiety and Depression Scale, depression sum score > 7. Overall model fit (Hosmer and Lemeshow test): $\chi^2 = 12.841$, df = 8, $n = 149$, $p = 0.117$.
Cox & Snell $R^2 = 0.030$, Nagelkerke $R^2 = 0.041$. 95% CI: 95% confidence interval; OR: odds ratio. *p*-values < 0.05 in bold.

Previous recurrent falls was the only significant risk indicator for future recurrent falls. This is a factor well known from falls research in elderly subjects (9, 10) and other neurological diagnosis (33) and was also shown by Nelson et al. in wheelchair users with SCI (5). None of the variables earlier shown as associated with recurrent falls in wheelchair users in previous studies, such as being male (3, 15), improved functional independence (SCIM III) (15), performing regular exercise (15), younger age (15) nor higher alcohol consumption (5) were shown to contribute to falls in the present study. In accordance with Nelson et al. (5), several participants reported spontaneously that they had fallen more during younger age, and earlier after the onset of SCI, when they were less skilled in wheelchair handling and transfers. Matsuda et al. (4) showed that participants with SCI who reported falling had a tendency to higher levels of physical activity, as was also indicated in an earlier study that included the present sample (15). This tendency was also evident in a study of individuals with multiple sclerosis (MS), in which subjects with impaired walking ability fell more than those who were not able to walk (34). However, this was not seen in the present study although going to work/studying might be a proxy for higher level of physical activity. Nelson et al. (5), showed that individuals with higher levels of functional independence fell more. In the present study this was only seen in the bivariate analysis and the association was lost in the multivariate analysis.

In contrast to the study by Kirby et al. (3), we found more than twice as many fall incidents indoors compared with outdoors. Apart from the differences in study design (retrospectively reported tips and falls since the start of wheelchair use in a mixed sample) they analysed only the location of the most serious falls. In addition, the development of wheelchairs has escalated since their study in 1994, which also complicates comparison. The present study found that most falls occurred during transfers or while pushing the wheelchair on an uneven surface. There seem to be a strong need for improved wheelchair driving and transfer skills, and wheelchair adaptations, as well as innovations regarding technical aids.

The findings in the present study, with many minor injuries and few serious ones (10%), are in line with previous research (3, 5), where 84–86% of the injuries were minor and 14–16% were serious. They also showed that male sex and younger age were factors associated with injurious falls. However, due to the different study designs, mentioned above, the results are difficult to compare.

Of the variables studied in the present analysis, general quality of life was the only significant risk indicator for fall-related injuries, as increasing quality of life was associated with decreasing odds ratio of having a fall-related injury. However, it could also be due to those who have many falls having a lower quality of life. Quality of life in relation to fall-related injuries has, to our knowledge, not yet been studied in this population. Interestingly, neither previous recurrent falls nor previous fall-related injuries were risk indicators for future injuries. This accentuates the importance of increased research in this field in order to improve the lives of individuals with SCI. Less severe SCI, use of psychotropic medication, overuse of alcohol and need for high activity were indicators shown to increase the risk of injuries severe enough to require medical attention in a study by Krause (16), who studied subsequent injuries after SCI with a 10-year follow-up. Notable is, that they did not study falls *per se*, but accidents in a broad perspective including falls. For injuries requiring hospital care, older age, SCI caused by violence, sensation-seeking behaviour and low sociability were reported to increase the risk (16). None of these indicators were significant in the present study (however sociability was not investigated). Based on a subsample of that study, Saunders & Krause (6) reported that only mode of mobility (wheeling equally to walking), and use of prescription medication were associated with having higher odds of fall-related injuries. Medication was not a significant indicator in the present study. An explanation might be that the participants in the study by Saunders & Krause had a slightly higher mean age (54.3 years) and a longer mean time since SCI (27 years), which might influence the prevalence and type of medication. Prescription of medication may also differ between countries.

Interestingly, the present study indicates that there might be different predictors for recurrent falls and injurious falls. Our knowledge about falls and their negative consequences in individuals ageing with disabilities is lagging far behind the knowledge about community dwelling older adults. Further research is needed to clarify whether these fall-related injuries contribute to further disabilities (6).

The definition of frequent or recurrent fallers has been discussed previously (35), and cut-off values of both more than one fall (33, 36–39) and more than 2 falls have been used (31, 39). Retrospectively reporting more than 2 falls has been shown to predict future falls dichotomized either as 0–1/>1 or 0–2/>2, and risk indicators for single falls have been shown to be weaker than for recurrent falls (10, 39). Registration of recurrent falls seems to be important, since elderly community-dwelling individuals experiencing more than 1 fall have been proposed as a distinct risk group, more vulnerable than single fallers (39). Among elderly individuals, those reporting the most frequent falls had a higher risk of incurring injurious falls, and registration of recurrent falls has been recommended to lead to comprehensive and detailed fall risk assessment (8).

Study limitations

This study has certain limitations. There is a risk of recall bias during the reporting period of 2 weeks; however, we supplied the participants with diaries for noting information about their falls and contacted them within days after a fall was reported. A reporting period of 2 weeks has previously been recommended in falls research (36), and with a 12-month follow-up design we considered that the risk of drop-outs would increase if the text messages were delivered more frequently. There is also a risk of under-reporting falls if the participants wanted to avoid being contacted or if they changed their behaviour and thereby fell less frequently due to their participation in the study, i.e. a Hawthorne effect. Sub-analysis of fall injuries was restricted due to the relatively limited sample. We also suspect that some participants might not have reported all minor injuries. We used a cohort of individuals attending their regular follow-up at the 2 SCI units, and we consider the results to be generalized to similar contexts.

Conclusion

Falls and recurrent falls seem to be common in wheelchair users with SCI, leading to a need for increased awareness about fall risk situations and fall-related injuries. Asking about previous falls is important to identify individuals at risk of future falls and fall-related injuries. Since lower general quality of life was associated with fall-related injuries this is an area that should be addressed in future research. It is also important to inform individuals with SCI, as well as rehabilitation staff, to pay attention to increased risk of falls when ill, when medication affecting spasticity is changed or when prescribing a new wheelchair. Since most falls occurred while pushing wheelchair on uneven surface or during transfers, there is a strong need for improved transfer and wheelchair skills during rehabilitation and whenever functional status is altered, and further improvement of technical aids is essential.

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