
Risk of Fall-Related Injuries among Ambulatory Participants with Spinal Cord Injury

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Background: With medical and rehabilitation advances, many people are able to regain or maintain ambulation after spinal cord injury (SCI). However, those who are ambulatory may be at increased risk for falls. **Objective:** To assess the relationships between walking devices and behaviors, including alcohol use, prescription medication use, and exercise, with falls among persons with SCI who are ambulatory. **Methods:** A total of 515 adults with chronic SCI who were able to ambulate provided self-report of their use of assistive devices for ambulation, prescription medication use, alcohol use, exercise, and falls resulting in injury (FRI). **Results:** At least 1 FRI was reported by 20.3% of participants in the past year. Ambulatory participants who reported using a wheelchair as their primary mode of mobility were less likely to have an FRI than those who reported walking more than using a wheelchair. Those with perceived poor balance were 2.41 times more likely to have an FRI than those without poor balance. Those who reported less exercise than other persons with a comparable SCI severity were 2.77 times more likely to have an FRI than those reporting the same or more amount of exercise. Pain medication misuse also was associated with higher odds of an FRI. **Conclusions:** Health care providers should be aware of the risk for FRI among those who are ambulatory. They should assess and consider not only ambulatory ability, but also behaviors, including prescription medication use and exercise, when recommending ambulation techniques. **Key words:** behavior, exercise, fall, pain medication, spinal cord injury

Spinal cord injury (SCI) results in permanent motor and sensory deficits and can elevate the risk of secondary health conditions¹ and mortality.^{2,3} As the proportion of neurologically complete injuries has decreased,⁴ and with advances in medical and rehabilitation care, many persons are able to regain or maintain ambulation. However, recent studies have identified that ambulation is associated with an increased risk of falls after SCI⁵ and is sometimes associated with negative health outcomes, including pain and depression.^{6,7}

Many ambulatory persons with SCI use assistive devices to help with walking.⁸ Even though these devices can aid with ambulation, there is evidence that certain devices may impede balance and increase risk of falls.⁹ Brotherton et al¹⁰ identified risk of falls (an unplanned, unexpected contact with the supporting surface) among persons with ambulatory SCI, finding that 75% reported at least 1 fall in the previous year. Among persons who are able to walk at least 10 m, it has been found that worse health (as measured by number of medical conditions), arthritis, and dizziness resulted in increased odds of a fall in the previous year.¹¹ Persons who used a cane were more likely

to fall than those who did not, and those who used a walker were less likely to fall than those who did not.¹¹ A recent study of falls in ambulatory individuals with SCI reported higher functional ability among persons classified as “fallers” compared to “non-fallers.”⁵ Although those studies were able to assess some predictors in relation to falls, they lacked the power to assess predictors in a multivariable model or assess multiple predictors simultaneously. Other research on falls among persons with SCI has been limited to falls among wheelchair users, excluding persons who are ambulatory. Falls in persons who are ambulatory could result in negative health outcomes, including fractures or further disability, but studies of predictive factors of those falls have been limited by sample size and scope of measurement.

In addition to the increased risk of falls with the use of some assistive devices, Saunders et al⁸ found that the use of 1 cane and the use of a wheelchair less than half the time for locomotion were associated

with increased odds of greater pain intensity, pain interference, and fatigue. These results suggest that persons who are only partially ambulatory or who use certain devices for ambulation are at increased risk for negative health outcomes. In addition, the consequences of a fall after SCI may be severe and result in added disability, as SCI is associated with bone density loss¹² and osteoporosis,¹³ which increases the risk of fracture.¹⁴

Behavioral and personality factors contribute to the events leading to SCI. Alcohol or drug use has been found to be a contributing factor to injury in 39% of SCIs.¹⁵ Furthermore, these behaviors have been shown to have an effect on postinjury outcomes and subsequent injuries as a result of an event or mishap, including falls.^{16,17} Brotherton et al¹⁰ found that participants did not perceive alcohol or prescription medication use to be related to falls; however, a larger study has yet to be completed to examine this relationship or to link these behaviors with falls resulting in injuries (FRI). Exercise has also been examined as a behavioral factor related to fall risk. Exercise frequency (days/week) has been shown to decrease the odds of falling in ambulatory individuals with SCI.¹¹

The purpose of this study was to assess the relationships between walking devices and behaviors, including alcohol use, prescription medication use, and exercise, with FRI among participants with SCI who are ambulatory.

Methods

Population

After institutional review board approval was obtained, participants were identified through 3 sources of records at a large specialty hospital in the southeastern United States, and data were subsequently collected via mail from a southeastern medical university. Participants were eligible if they met 3 inclusion criteria: (1) 18 years or older at the time of assessment, (2) minimum of 1 year post injury, and (3) traumatic SCI with residual effects. Of 2,370 participants meeting these criteria, 1,544 responded (65.1%). For this study, we added another criterion, ability to walk, which further reduced the sample to 515.

Procedures

Data were collected through self-report by mail. Potential participants were sent an introductory letter describing the study and letting them know that materials would be sent 4 to 6 weeks later. A second set of materials was sent to nonresponders. Phone calls were made to those who did not respond to the second request, and additional materials were sent to those who expressed interest but had misplaced materials. Extensive efforts, including the use of multiple search engines, were made to identify current addresses of potential participants. Participants were offered \$50 remuneration for participation.

Measures

Our primary outcome was FRI in the past year. FRI were assessed by the question, "In the past year, how many falls have you had that resulted in an injury serious enough to receive medical care in a clinic, emergency room, or hospital." We chose to focus on FRI to identify the falls that affected the health of the individual as well as to help minimize recall bias. For analyses, we dichotomized our outcome, because there were not enough persons reporting 2 or more FRI for additional analyses.

A set of questions was designed to identify ambulatory status, devices used for ambulation, need for assistance from others, and maximum walking distance.¹⁸ Ambulation status (yes/no) was measured by a single question: "Are you able to walk at all?" All those who were able to walk were retained in the analysis (n = 515). Participants were asked if they used a walker (standard or rolling), canes or crutches (0, 1, 2), short leg braces (0, 1, 2), or long leg braces (0, 1, 2). They were also asked if they used other people to assist them when they walked. Maximum walking distance was assessed using 3 self-reported distances, each of which was anchored against distances reported as benchmarks in the literature: 10 m (almost 33 ft; Walking Index for Spinal Cord Injury [WISCI]),¹⁹ 150 ft (half a football field; FIM),²⁰ and 1,000 feet (over 3 football fields; average distance walked for adults with disabilities during a community trip).²¹ Participants were also asked about the relative portion of time they spent walking versus time

using a wheelchair at home and in the community: (a) walk more than wheel, (b) walk and wheel about equally, and (c) wheel more than walk. To assess walking quality, we asked participants to compare their balance and walking speed with persons of the same age and stature without a disabling condition. Participants were categorized for balance as being more unstable or about the same and for walking speed as being slower or about the same.

Alcohol use was assessed using questions from the Behavioral Risk Factor Surveillance System.²² Participants were asked (a) the number of days they drank any alcoholic beverages in the past month, and (b) how many times during the past month they had 5 or more drinks on one occasion. Responses to these 2 questions were used to classify participants as (1) nondrinkers (had 0 drinks in the past month), (2) drinkers (had alcohol but did not binge drink), and (3) binge drinkers (had 5 or more drinks on at least 1 occasion). Exercise was assessed by asking, "How much exercise do you get compared to other people with SCI who have about the same severity of injury: much less, less, about the same, more, much more, don't know?" Participants were grouped as 1 = *much less/less*, 2 = *don't know*, 3 = *same/more/much more*.

The Pain Medication Questionnaire (PMQ) was used to assess pain medication misuse.²³ The PMQ is a 26-item questionnaire. If 1 question was missing out of the 26, the average of the other 25 was used to calculate the missing score. Total scores ranged from 0 to 104, with a cut-point of 25, which has been previously used to indicate problematic pain medication use.^{23,24} The PMQ has been found to have acceptable reliability, and high PMQ scores were found to be related to history of substance abuse, psychosocial distress, and poor functioning.²³

Injury level was categorized as cervical 1-4 (C1-C4), cervical 5-8 (C5-C8), and noncervical. Demographic variables of gender, age at survey, and years post injury were also assessed.

Analyses

Analyses were conducted using SAS v.9.2 (SAS Inc., Cary, NC). We assessed the bivariate

relationships between the demographic variables, assistance/devices variables, and behaviors with our outcome (FRI), using chi-square and *t* tests. After assessing these relationships, we built a model of our outcome with the variables associated with the outcomes in step 1. We used a cut-point of $P < .15$; however, current age was included in both models as a statistical control regardless of significance. A multivariable model was then built using these results. Logistic regression was used, and odds ratios (OR) and 95% confidence intervals (CI) were given. All variables significant from the bivariate tests were entered simultaneously and eliminated one by one if a variable failed to reach statistical significance ($P < .05$).

Results

Just fewer than 70% of the participants (69.7%) were male, and 72.4% were White. Twenty-four percent had a C1-C4 injury level, 31.1% had a C5-C8, and 44.6% had a noncervical injury. The average (SD) age at survey was 50.2 (14.1) with an average (SD) of 13.7 (8.7) years post injury. Motor vehicle accidents were the most frequent cause of SCI (51.9%), followed by falls (17.0%), sports (11.4%), and violence (9.9%).

FRI were reported by 20.3%. Among participants sustaining an FRI, 56.3% reported 1 FRI, 20.8% reported 2 FRI, 8.3% reported 3 FRI, and 14.6% reported 4 or more FRI. In the bivariate analyses (**Table 1**), none of the demographic or injury variables were significantly associated with having an FRI. Percent of time spent walking at home was related to FRI; those who reported walking and wheeling equally were most likely to have had an FRI (46.4%), whereas those who reported wheeling more than walking were the least likely (10.9%). Both poor balance and slower walking were associated with an FRI. Need for another person to assist with walking was marginally associated with having an FRI ($P = .0996$). We found that using 1 cane or crutch was associated with an FRI in the past year, but no such relationships were observed with braces. Finally, exercise and pain medication abuse were related to FRI.

Using results from **Table 1**, we generated logistic regression models for FRI (**Table 2**). Use of persons

Table 1. Bivariate analyses of demographics, assistance and devices, and behaviors in relation to falls resulting in injury

	Falls		P value
	No	Yes	
Demographics			
Current age	50.1 (14.2)	49.5 (13.8)	.7023
Years post injury	13.8 (9.0)	13.4 (7.8)	.7306
Gender			.7946
Male	79.4	20.6	
Female	80.4	19.6	
Injury level			.8565
C1-C4	78.3	21.7	
C5-C8	81.0	19.0	
Noncervical	79.6	20.4	
Walking quality			
Maximum walking distance			.9788
<10 m	80.0	20.0	
10 m	79.4	20.6	
150 ft	78.6	21.4	
1,000 ft	80.4	19.6	
% time walking at home			.0001
Walk more than wheel	79.8	20.2	
Walk and wheel equally	53.6	46.4	
Wheel more than walk	89.1	10.9	
% time walking in the community			.2993
Walk more than wheel	81.2	18.8	
Walk and wheel equally	68.1	31.8	
Wheel more than walk	81.8	18.3	
Walk slower			.0050
No	86.4	13.6	
Yes	76.4	23.6	
Poorer balance			<.0001
No	88.9	11.1	
Yes	74.2	25.8	
Assistance/devices			
People			.0996
No	82.1	17.9	
Yes	72.6	27.5	
Walker			.3215
No	80.9	19.1	
Standard	82.0	18.0	
Rolling	73.1	26.9	
Cane/crutch			.0003
No	87.1	12.9	
1	71.2	28.8	
2	78.8	21.2	
Braces			.1839
No	80.8	19.2	
1	75.6	24.4	
2	88.5	11.5	
Behaviors			
Exercise			<.0001
Much less/less	65.4	34.6	
Don't know	74.2	25.8	
Same/more/much more	86.9	13.1	
Alcohol			.9061
No	80.7	19.3	
Yes, but don't binge	79.4	20.6	
Binge	78.6	21.4	
Pain medication misuse			.0027
No	80.7	19.3	
Yes	64.2	35.8	

Table 2. Multivariable logistic regression model for having sustained a fall resulting in injury

	Odds ratio (95% CI)	P value
Current age	1.01 (0.33-1.03)	.3900
People assisting with ambulation (vs no)		.0770
Yes	2.22 (0.92-5.39)	
% time walking at home (vs walk more than wheel)		.0004
Walk and wheel equally	2.39 (0.95-6.06)	
Wheel more than walk	0.26 (0.11-0.61)	
Poorer balance (vs no)		.0017
Yes	2.41 (1.33-4.38)	
Exercise (vs same/more/much more)		.0044
Much less/less	2.77 (1.51-5.09)	
Don't know	1.62 (0.76-3.46)	
Pain medication misuse (vs <25)		.0071
25+	2.53 (1.29-4.97)	

to assist with walking was marginally associated with having an FRI ($P = .0770$). Percentage of time walking at home remained in the model, and those who reported walking and wheeling equally had 2.39 times the odds of FRI than those who walked more than using a wheelchair (95% CI, 0.95-6.06). Additionally, those with poor balance also had increased odds of FRI (OR, 2.41; 95% CI, 1.33-4.38). Last, both exercise and problematic pain medication use were associated with having FRI in the past year. Persons reporting much less/less exercise had increased odds of having FRI (OR, 2.77; 95% CI, 1.51-5.09) compared to those with a comparable SCI who reported same/more/much more exercise. Participants who reported pain medication misuse had 2.53 the odds of having FRI than those who did not report misuse (95% CI, 1.29-4.97).

Discussion

This study adds to a surprisingly small body of existing research addressing FRI after SCI. Research has focused primarily on falls in general (not just those resulting in injury) and suggests that an

elevated risk of falls occurs after SCI, particularly among those who are ambulatory.^{10,11} The current study extends earlier findings by identifying an elevated risk of FRI among ambulatory individuals with SCI using a much larger participant cohort than has been used in previous research,^{10,11} by identifying both behavioral (pain medication use, exercise, alcohol use) and functional (percent of time spent walking, poor balance) factors related to FRI. We found 20.3% of participants had an FRI in the past year, which is similar to results from Kinne et al²⁵ that showed 20.6% of persons with disability reported falls or other injuries in the previous year. Additionally, they reported that only 6.9% of participants in their study reported falls or other injuries in the previous year.

There are several important clinical implications of the current findings for ambulatory individuals with SCI and rehabilitation professionals. First, the elevated risk of FRI that is associated with unilateral cane and crutch use suggests the need for consideration of bilateral supports. Previous research has indicated greater levels of pain severity, pain interference, and fatigue among persons who use unilateral supports,⁸ so there appears to be a larger pattern of secondary health conditions that may develop in conjunction with use of unilateral supports. Whether or not this relationship is causative cannot be determined from the current data, yet the pattern of results is of concern. The use of pain medications is also associated with a substantially higher risk of FRI. Additionally, we found, among those ambulatory, that persons who reported spending equal time walking and wheeling had the highest odds of having an FRI. Previous research has found an increased incidence of falls among persons with the greatest independence⁵ but did not include persons who were not independent in ambulation. Our study suggests that persons who do not have a primary mode of locomotion (either walking or wheeling) are at increased risk for an FRI.

The relationship between pain medication use and FRI is complicated by the multiple aspects of service provision. First, the physical therapist, who is working to maximize an individual's function and ambulation, needs to realize that he or she may ambulate in conditions that are

not functional and have pain complications as a result. Because ambulation is an important goal for persons with SCI, they may ambulate in instances where it is not truly functional or practical. This may lead to an increased risk of FRI. We found that persons who were ambulatory the majority of time reported fewer FRI. Similarly, reliance on others for assistance in ambulation was associated with a greater risk of FRI; therefore, ambulating under circumstances that are less than ideal may compromise safety. The therapist should be aware of the possibility that the individual may be using pain medication. The medication can mask the patient's lack of functional ability and can affect an individual's judgment and balance, which will increase the risk of falls when he or she ambulates in the community. Second, those who prescribe medications need to do so cautiously with those who are ambulatory and those who are not yet functionally ambulatory and raise fundamental questions as to whether there are other means of pain management or whether the rehab program should be modified to focus on weight-bearing activity instead of nonfunctional ambulation to obtain the benefits associated with weight bearing (psychological, prevention of osteoporosis). Third, mental health professionals should screen for pain medication abuse to promote patients' safety and identify substance abuse disorders that may hinder their participation and quality of life. Last, the relationship among pain medication abuse, ambulation, and the risk of FRI demonstrates the importance of an interdisciplinary approach where goals are defined based on ambulatory ability as well as risk of adverse outcomes. We all want to be sensitive to the goals of persons with SCI, and functional recovery in ambulation will always be a primary stakeholder goal.

In addition to the relationship between pain medication use and FRI, we found that persons who reported poorer balance and much less/less exercise were at increased odds for FRI. Rehabilitation professionals must be resolute in applying the same scrutiny to ambulation as to any other rehabilitation goals, balancing the benefits with the risks and sharing this information with the stakeholders who ultimately make the decisions and whose outcomes are affected by these practices. In some instances, providers need

to inform patients that the use of less assistance (ie, unilateral support) may not be best approach for attaining their goal for ambulation. Additionally, for persons who cannot walk without assistance or increased pain medication, providers may recommend dynamic standers for weight bearing and exercise. Providers should emphasize the importance of exercise in relation to successful ambulation and in minimizing the risk of FRI.

Limitations

Although this study provides needed information on FRI among ambulatory persons with SCI, there are several limitations. All data are self-report. Therefore, they are subject to recall bias. This applies to issues of accuracy of reporting. We attempted to minimize this by using standard questions about objectively verifiable information, not individual perceptions or ratings of outcomes. Additionally, we limited the reporting of our primary outcome (FRI) to occurrences in the previous year to minimize recall bias. We only focused on FRI, so we cannot directly compare our results to studies that focused on all falls. Assessment of pain medication abuse is also subject to self-report bias, including intentional distortion or unintentional distortion by social desirability. Because this study is covered by a certificate of confidentiality, the intentional distortion should be minimized as repercussions for accurate reporting are minimized. Additionally, as this is a cross-sectional study, we are unable to establish temporality between the predictors and the outcome. Finally, all participants were identified through the same facility in the southeastern United States, thus results may not be fully generalizable to other regions.

Conclusion

The probability of FRI among persons who are ambulatory after SCI is affected by pain medication use, use of a unilateral support (cane or crutch), and gait that requires assistance from another or is used less than half of the time. The findings strongly suggest the need to balance the goal of ambulation with its functional benefit and the increased risk for FRI. Intervention strategies should include prevention of pain and

overprescription of pain medications, the search for alternative strategies to promote mobility in instances of marginal ambulation, and the need for screening and treatment for pain medication use among persons whose ambulation is limited in terms of functionality.

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