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ORIGINAL ARTICLE

Falls in independent ambulatory patients with spinal cord injury: incidence, associated factors and levels of ability

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Study Design: A 6-month retrospective study.

Objectives: To investigate incidence and factors associated with falls in independent ambulatory patients with spinal cord injury (SCI), and to compare levels of ability in those with and without a history of falls.

Setting: A tertiary rehabilitation center and community hospitals.

Methods: Seventy-seven independent ambulatory subjects with SCI were interviewed for fall data during 6 months before participation in the study. Subjects were also assessed for their functional ability using the timed up and go test (TUGT) and the 6-min walk test (6MinWT).

Results: Twenty-six subjects (34%) reported falls during 6 months (range 1–6 times). After falls, two subjects required medical attention due to wrist joint fracture and back pain. Walking without a walking device significantly increased the risk of fall, whereas using a walker significantly reduced the risk of fall ($P < 0.05$). Moreover, faller subjects showed significantly better levels of ability than the non-faller subjects ($P < 0.005$ for the TUGT and $P < 0.05$ for the 6MinWT).

Conclusion: Approximately one-third of the independent ambulatory subjects with SCI experienced falls. Notably, faller subjects had better functional ability than the non-faller subjects. Thus, apart from emphasizing the ability to walk independently, rehabilitation professionals may need to seek strategies that improve balance and safety.

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INTRODUCTION

Patients with spinal cord injury (SCI) encounter sensorimotor dysfunctions that reduce ability of movement control and subsequently increased risk of falls.[1–4] Previous studies have reported that independent ambulatory patients with SCI encounter a high-risk of falls (74–75%).[2,5] The incidence is clearly higher than that reported in the elderly (33%)[6,7] and patients with other neurological disorders such as stroke (37–73%)[8,9] and Parkinson's diseases (51–68%).[10,11] After falls, 18% of subjects with SCI reported fracture and 45% had restricted ability to get out into communities and engage in a productive activity.[2] Amatachaya *et al.*[5] also found that, among 17 faller subjects, seven of them had bruises, one reported muscular pain and one experienced metatarsal bone fracture that required medical attention and readmission with limitation of weight bearing for 14 days. Subjects in these studies indicated the reduction of balance control and muscle weakness as major factors relating to falls.[2,5]

Until now, there is only little evidence on falls in individuals with SCI. Brotherton *et al.*[2] retrospectively surveyed falls in independent ambulatory patients with SCI in 1 year. However, a retrospective design using a long follow-up period and self-reported data may have an increased chance of recall bias.[12,13] In addition, there were a large number of non-responders in which selective attrition/response could affect findings of the study.[14] Amatachaya *et al.*[5] prospectively assessed falls over 6 months after discharge. Nonetheless, the study recruited only 23 independent ambulatory subjects with SCI. The factors

associated with falls were also subjectively reported by the subjects, which might not reflect actual impairments.[5] Therefore, this study further explored incidence and factors associated with falls in independent ambulatory patients with SCI over 6 months before participation in the study. Furthermore, the study compared functional ability between patients with and without a history of falls.

MATERIALS AND METHODS

Subjects

The researchers invited independent ambulatory patients with SCI who visited an outpatient and inpatient department in a tertiary rehabilitation center and community hospitals in Thailand. The inclusion criteria were age at least 18 years, having an SCI from either traumatic or non-traumatic causes, and ability of independent walking with or without a walking device over at least 17 m continuously (functional independent measure locomotor (FIM-L) scores 5–7). The patients were excluded if they had an SCI from progressive diseases, and other medical conditions or complications that might affect/limit mobility, such as pain in the musculoskeletal system with a pain scale more than 5 out of 10 on a visual analog scale, leg length discrepancy, deformities in the joints of extremities, urinary tract infection or pressure ulcer that required bed rest. The eligible subjects needed to provide a written informed consent approved by the local ethics committee before taking part in the study.

Protocols of the study

Subjects were interviewed for their baseline demographics and SCI characteristics, and underwent screening tests to ensure levels and severity of SCI

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(American Spinal Injury Association Impairment Scale or AIS classification). Subsequently, they were interviewed for fall data during the 6 months before participation in the study using a questionnaire (Supplementary appendix). The questionnaire was developed through consolidation of data from previous studies[2,15] and with the assistance of four experts (two physical therapists, a nurse and a physician) who had good clinical experience in patients with neurological conditions. Then the questionnaire was preliminarily tested in 10 independent ambulatory patients with SCI. Thereafter, some items were deleted, modified or rearranged in order to improve the clarity and completeness of the questionnaire. After revision, the questionnaire contained both closed-end and opened-end questions that were divided into three parts, including baseline demographics, SCI characteristics and fall information (see appendix), and required approximately 20–30 min to complete.

For the objective of this study, a fall was defined as an unplanned, unexpected or unintentional event that resulted in a person coming to rest on the ground, or any other lower or supporting surface during standing, walking or changing posture.[2,5] Data for each fall were verified by asking the date, time, place and consequences of the fall. The findings were further confirmed by their relatives or a care giver.

Furthermore, subjects were assessed for their functional ability using the timed up and go test (TUGT) and the 6-min walk test (6MinWT). The TUGT recorded the time required to accomplish the tasks of standing up from a standard arm chair, walking at a fast and safe pace along a 3-m walkway and returning to sit down on the chair. The 6MinWT measured the longest distance walk in 6 min along a smooth rectangular walkway in order to minimize the effects of turning on the outcomes.[16–18] Results of the test were also used to confirm baseline walking ability (FIM-L scores). In order to minimize the effects of routine treatments on the outcomes, inpatient subjects needed to complete the study within 2–3 days after admission.

Statistical analyses

Descriptive statistics were applied to explain baseline demographics, SCI characteristics and findings of the study. Multiple logistic regression analysis was used to determine factors relating to falls. The independent-samples *t*-test was utilized to compare the data of the TUGT and 6MinWT between faller and non-faller subjects. Levels of significant differences were set at $P < 0.05$.

RESULTS

Eighty-two independent ambulatory patients with SCI completed the study. However, data for five subjects were excluded because their functional ability data were outliers and extreme. (This refers to the data that were more than 1.5 times of the interquartile range below the first quartile or above the third quartile. The interquartile range is the difference between the third and first quartiles or Q3—Q1. Thus, the data (*x*) were considered as outliers and extreme, and subsequently excluded if they were less than $Q1 - (1.5^*$ interquartile range) or more than $Q3 + (1.5^*$ interquartile range)).[19] As a result, the study analyzed data from 77 subjects. Most of these subjects were males at a chronic stage of injury, and had an SCI from non-traumatic causes. Two subjects could walk with a walker independently less than 50 m (FIM-L 5, the longest distance walk = 24 and 38 m, respectively), 40 subjects were able to walk independently with a walking device at least 50 m (FIM-L 6, the average longest distance walk in 6 min (mean ± s.d.) = 110.23 ± 41.60 m (range 82.34–142.13 m)), and the rest of them could walk independently at least 50 m without using any walking device (FIM-L 7, the average longest distance in 6 min (mean ± s.d.) = 284.68 ± 63.48 m (range 235.82–332.38 m)). Other baseline demographics and SCI characteristics of subjects are given in Tables 1 and 2.

Twenty-six subjects (34%) experienced falls during 6 months before participation in the study (range 1–6 times/subject). Thus, the total number of falls was 55, in which 36 falls occurred while walking, 6 falls happened during standing and the rest occurred while changing

Table 1 Baseline demographics and functional ability of subjects

Variables	Non-faller subjects (n = 51)	Faller subjects (n = 26)	P-value[a]
Age (years)	52.8 ± 12.3	48.9 ± 11.6	0.176
Body mass index (kgm^{-2})	23.8 ± 3.9	22.4 ± 3.5	0.612
Postinjury time (months)	52.2 ± 56.4	52.2 ± 44.0	0.996
Timed up and go test (s)	23.9 ± 13.0	16.3 ± 7.9	0.008[b]
6-min walk test (m)	160 ± 88.8	201.3 ± 72.8	0.044[b]

Note: the data are presented using mean ± s.d.
[a]P-value from the independent-sample *t*-test.
[b]Indicated significant differences between the groups.

posture. The falls happened only in subjects with FIM-L 6 ($n = 9$) and FIM-L 7 ($n = 17$), but not in subjects with FIM-L 5. After falls, two subjects required medical attention due to wrist joint fracture and back pain. The consequences reduced their ability to conduct daily activities and participate in a community. There were no significant differences of age, body mass index and postinjury time between faller and non-faller subjects ($P > 0.05$, Table 1). However, the TUGT and 6MinWT data of the faller subjects significantly differed from those of the non-faller subjects (Table 1). The multiple logistic regression analysis suggested that walking without a walking device significantly increased the risk of fall whereas using a walker significantly decreased the risk of fall ($P < 0.05$, Table 2).

DISCUSSION

This study explored falls and compared functional ability in 77 independent ambulatory SCI subjects with and without a history of falls. The findings showed that 26 subjects (34%) experienced at least one fall during 6 months before taking part in the study (range 1–6 times/subject). Most falls happened during walking. After falls, two subjects suffered from serious medical consequences that affected mobility. Walking without an ambulatory device significantly increased the risk of falls, whereas walking with a walker significantly reduced the risk of fall ($P < 0.05$, Table 2). Findings of the TUGT and the 6MinWT also emphasized that the faller subjects had better levels of functioning than the non-faller subjects ($P < 0.05$, Table 1).

The study applied the TUGT and the 6MinWT to assess the functional ability of the subjects because the previous studies[2,5,20] indicated that the impairments of balance control and muscle strength were the major causes of falls in subjects with SCI. Apart from standard walking, the TUGT also incorporates functional elements of sit-to-stand and balance control.[17] Van Hedel *et al.*[16,18] suggest that the 6MinWT is one of the best thorough investigations that the results correlate with other walking ability tests, that is, the walking index for SCI II and the 10-m walk test. Results of the test also associate with strength of the hip flexors and abductor muscles, which are the key determinants for walking ability.[21] Unexpectedly, the data suggested that subjects with good functional ability (walked without a walking device, required less time to complete the TUGT and achieved longer-distance walk in 6 min) encountered a risk of falls. The findings differed from those reported in elderly and other groups of patients where faller subjects had less functional ability than non-faller subjects.[22,23] A possible explanation for the findings may be that better functional ability may increase the integration of walking into daily activities and be less wheelchair dependence. High ability levels may also accompany greater confidence and less attention to movements. Therefore, these subjects have increased exposure to fall opportunities and have a high risk of falls.

Table 2 Factors associated with falls: unadjusted and adjusted odds ratio (uOR and aOR) comparisons

Variable	Total (n)	Non-faller, n (%)	Faller, n (%)	uOR (95% CI)	P-value	aOR (95% CI)	P-value
Gender							
Female	23	17 (74)	6 (26)	1	0.352	1	0.292
Male	54	34 (63)	20 (37)	1.67 (0.58–4.77)		2.02 (0.55–7.43)	
Cause							
Traumatic causes	29	20 (67)	7 (35)	1	0.694	1	0.218
Non-traumatic causes	48	31 (65)	17 (35)	1.22 (0.46–3.20)		2.26 (0.62–8.31)	
Level of injury							
Tetraplegia	26	17 (65)	9 (35)	1	0.910	1	0.940
Paraplegia	51	34 (67)	17 (33)	0.94 (0.35–2.51)		1.05 (0.28–3.89)	
AIS classification							
AIS D	52	34 (65)	18 (35)	1	0.820	1	0.752
AIS C	25	17 (68)	8 (32)	0.89 (0.33–2.42)		1.25 (0.32–4.91)	
Stage of injury							
Subacute stage ($\leqslant$12 months)	12	9 (75)	3 (25)	1	0.485	1	0.775
Chronic stage (>12 months)	65	42 (65)	23 (35)	1.64 (0.43–6.14)		1.25 (0.27–5.76)	
Using a walking device							
Yes	42	33 (79)	9 (21)	1	0.012[a]	1	0.049[a]
No	35	18 (51)	17 (49)	3.46 (1.30–9.19)		3.47 (1.00–14.87)	
Types of a walking device							
No	35	18 (51)	17 (49)	1		1	
Cane	14	10 (71)	4 (29)	0.42 (0.12–1.55)	0.201	4.45 (0.08–2.38)	0.346
Crutches	5	3 (60)	2 (40)	0.71 (0.13–4.06)	0.719	0.70 (0.07–6.69)	0.757
Walker	23	20 (87)	3 (13)	0.16 (0.04–0.60)	0.005[a]	0.12 (0.02–0.73)	0.022[a]
Having a caregiver							
Yes	51	37 (73)	14 (27)	1	0.101	1	0.396
No	26	14 (54)	12 (46)	2.26 (0.85–6.00)		1.63 (0.53–5.09)	
Fear of falling							
Not at all	15	7 (47)	8 (53)	1		1	
Mild to moderate	40	29 (72)	11 (27)	0.33 (0.99–1.101)	0.073	0.07	0.296
Very to most	22	15 (68)	7 (32)	0.41 (0.11–1.59)	0.190	0.65	0.589

Abbreviation: AIS = American Spinal Injury Association (ASIA) Impairment Scale.
[a]Odds ratio is significantly different from 1.0 (P<0.05).

Moreover, the findings indicated that using a walker reduced the risk of falls. Bateni and Maki[24] indicate that a walker greatly enlarges the body base of support. Subjects could advance the device during a double support phase, which obviously increased postural stability and therefore decreased the risk of fall of the subjects. However, long-lasting use of a walker poses negative impacts on the patients, such as induced abnormal posture and musculoskeletal pain, requiring high-attention demand and energy expenditure, and increased risk of fall due to limited forward and lateral movements of the legs.[24,25] Thus, the findings may imply that, apart from levels of functioning (ability of independent walking), rehabilitation professionals may need to explore treatment strategies to improve safety issues for patients. For example, instead of training in an empty room without disturbing factors, physical therapists may need to incorporate contextual conditions that the patients may encounter at home and community in order to optimize their balance and subsequently minimize the risk of fall. However, there is a need of evidence to support this assumption.

The findings of this study reflect those of Brotherton et al.,[20] who found that using more supportive walking devices, that is, walkers, decreased the risk of fall, whereas walking with a less supportive device, that is, cane, increased the risk of fall. Simpson et al.[26] also demonstrated that faller subjects with stroke required significantly less time to complete the TUGT than the non-faller subjects. The different incidence of falls found in this study and the previous reports[2,5,20] may relate to study design, follow-up period and the sample size. Although the data in this study were retrospectively gathered, the researchers attempted to minimize recall bias by decreasing the time interval to 6 months[5] and interviewing for associated data such as time, place and consequences of each fall with confirmation from their relatives or a care giver. The subjects were recruited mainly from a tertiary rehabilitation center that limited the number of sample size. However, this rehabilitation center captures a large number of patients with SCI in the northeast area of Thailand. In order to increase the number of sample size, the researchers recruited both inpatient and outpatient subjects and those from community

hospitals. However, admission in a hospital may increase the effects of other confounding factors, that is, regular treatments, on the outcomes. Therefore, inpatient subjects who were eligible as per the inclusion criteria needed to complete the study within 2–3 days after admission.

In addition, there are some other noteworthy limitations of the study. The ability of walking with or without a walking device was classified according to the subjects' preference in order to represent their usual lifestyle. Nonetheless, using such criteria might influence the findings; for example, subjects might actually need a walking device but they may refuse to use any, which will increase the risk of fall. However, the baseline walking ability (the longest distance walk) may support the classification, that is, subjects who walked without a walking device could walk obviously longer than those who walked with a walking device. Nevertheless, a further study using a prospective design in a larger number of subjects with the information of medical prescription on the use of a walking device is needed to confirm the findings. Moreover, the incorporation of additional measures (for example, Berg Balance Scale) might help to clarify factors relating to falls following SCI.

DATA ARCHIVING
There were no data to deposit.

CONFLICT OF INTEREST
The authors declare no conflict of interest.

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Supplementary Information accompanies the paper on the Spinal Cord website (http://www.nature.com/sc)