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Fall incidence and associated factors in spinal cord injury patients who walk with or without an ambulatory assistive device

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ABSTRACT

Background: The majority of ambulatory individuals with spinal cord injury (SCI) require an ambulatory assistive device (AAD). However, the association between falls and gait aid use is still inconsistent. Subgroup analysis may provide the opportunity to differentiate these factors more clearly.

Objectives: This study aimed to explore fall incidence and associated factors in SCI patients who walk with or without an AAD.

Materials and methods: Ninety-seven participants were interviewed for their baseline demographic data, physical activity, history of falling and fear of falling. They were divided into 2 groups, AAD and non AAD group. They were assessed with three functional tests, including the Timed Up and Go Test, Five Time Sit to Stand Test and 10 Meter Walk Test. Then fall data was followed for six months.

Results: More than one-third of all participants experienced at least one fall (40%). The results also showed that the proportion of falls in the AAD group was slightly greater than that of the non-AAD group (AAD=46% and non-AAD=32%). In the AAD group, a multiple variable analysis indicated a significantly higher fall rate among those who were younger than 50 years, used a cane or crutches and had moderate to high physical activity. For the non-AAD group, it was found that poor balance and a history of falls were strong factors associated with more falls.

Conclusion: Falls were a serious issue for the participants who walk with or without an ADD. However, the factors affecting falls in these two groups were different. Thus, therapists should consider the factors associated with falls for each group of SCI patients separately to provide proper rehabilitation that prevents falls and subsequent injury.

Introduction

Nowadays, approximately 80% of individuals with incomplete spinal cord injury (iSCI) can regain their walking ability.[1] However, the majority of ambulatory iSCI require an ambulatory assistive device (AAD) (64%), while 36% of these individuals walk without an ADD.[2] To alleviate reduced quality of ambulation, gait aids are commonly prescribed for those with muscle weakness, and poor weight bearing and mobility[3]. Although gait aids can be helpful for maintaining balance, improper use of AAD contributes to increased energy expenditure, an unsteady gait, overload, joint damage and a higher risk of fall.[3-4] A previous study reported that AAD users were more likely to fall than non-AAD users.[5] Nevertheless,

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Phonthee *et al*. found that iSCI walking independently without gait aids reported an increased risk of fall.[6] The injuries resulting from falls in patients with SCI have been reported as including muscle pain, wounds, ligament tears and fractures.[7] Moreover, functional restriction, fear of falling, social isolation, depression, and hospitalization may occur as consequences of falls.[8] Musselman *et al*.[9] investigated intrinsic fall risk factors based on clinical and laboratory measurement. They found that lower extremity weakness, loss of balance-evaluated by centre of pressure (COP) velocity in mediolateral (ML direction)-and low gait speed were factors contributing to future falls. In addition, several other studies have indicated that functional impairments, less exercise, a history of falls, fear of falling (FOF) and walking device use were all strongly associated with fall risk in these individuals.[7,10–13]

However, the association between falls and gait aid use is still inconsistent. Subgroup analysis may provide the opportunity to differentiate these factors more clearly. Therefore, the aim of prospective study was to explore fall incidence and associated factors in ambulatory iSCI who walk with or without an ADD.

Materials and methods

Participants

One hundred and three SCI patients agree to participate in this study. However, one person in AAD group and five individuals in non-AAD group were drop out during follow up period due to the personal reasons. Therefore, 97 participants completed the study. The participants were enrolled from a tertiary rehabilitation centre and community in the northeast area of Thailand. The sample size calculation using from pilot study.

Participants were identified by clinicians from a specialty hospital and recruited at a tertiary rehabilitation centre and in communities in northeast Thailand. The participants were at least 18 years of age, included both traumatic and non-traumatic causes (American Spinal Injury Association Impairment Scale [ASIA] C and D) and were able to ambulate at least 17 meters either with or without an AAD (FIM-L scores (Functional independence measure locomotor) = 5-7). Exclusion criteria included patients who were unable to understand and follow commands, had a leg length discrepancy, were pregnant, or had any underlying disease that caused pain (visual analog scale more than 5). This study was approved by the local ethics committee (HE611187), and the eligible participants gave their written informed consent before participating in the study.

Protocol

The eligible participants were interviewed for their baseline demographics, SCI characteristics, physical activity, fear of falling, fall history and associated factors using incidence of fall and associated factors Thai version questionnaire.[6] Physical activity (PA) measured by interview their activities and using MET (The metabolic equivalent of task) to indicate their intensity.[6,14] Then each participant was assessed for balance using the Timed Up and Go Test (TUGT), walking speed using the 10 Meter Walk Test (10MWT) and lower limb strength test using the Five Times Sit to Stand Test (FTSST). In addition, participants were asked to track falls for the subsequent 6 months using monthly fall calendars, and researchers visited participants during the third and sixth months to ensure that falls data-including how many falls, the circumstances of each fall and consequences of falling -was being recorded.

TUGT was used to measure balance performance. The method required stopwatch, a standard chair (height: 43 cm) and tape (mark 3 m). The subject's started in a sitting position with their back closed to the backrest 90 degree and their feet placed on the floor slightly behind the knee. Then, stood up upon assessor's command "Go" then walked for 3 meters, turned around and went back to the chair and sat down. The time would be stopped when the subjects sat on the chair against the backrest. The subjects were allowed to use an assistive device. Subjects performed 3 trials/test and calculated the average times of 3 trials.[15]

The 10-meter walk test was a walking speed assessment. The testing device was included stopwatch, and measuring tape (mark 10 meters walkway, add mark at 3 and 7 meter). The participants walked with or without assistance for 10 m, allow for 3 m acceleration and 3 m deceleration. Assistive device could be used, the test began when the iliac crest passed the 3 meters mark and stopped timing when the iliac crest passed the 7 meters mark. The test measured the time in middle 4 meters of walkway. Subjects walked with their preferred speed. Perform three attempted and average value of 3 trials were calculated.[16]

The FTSST was used to measure lower limb muscle strength during changing position form sit to stand. The equipment of the test was stopwatch and standard armless chair (with a seat height of 43 m). Participants sat with both arms cross the chest, their back closed to the chair and feet placed on the floor with slightly behind the knee. Participants were required to stand up with the hip and knee fully extension and sit down 5 times as fast and safe as possible. If the participants unable to stand up five times independently, they were allowed to press their hands down against a standard walker while performed FTSST. Timing began at "Go" and end when their back against the backrest on the fifth repetition. Participant performed 3 trial/test and calculated the average of 3 trials.[17]

Statistical analysis

Data were gathered using the SPSS IBM version. A descriptive statistic was applied to explain baseline demographic and SCI characteristic data. A chi-square test was utilized to compare categorical data, and an independent t-test was used to compare normally distributed continuous data. A Mann-Whitney U-test was used for non-normally distributed continuous data. A multiple logistic regression analysis was used to determine factors associated with falls among ADD and non-ADD users. The results were reported in terms of

unadjusted and adjusted odd ratios (aOR) with 95% CI, and significance was set at $p<0.05$.

Results

A total of 97 participants were eligible based on the criteria and agreed to participate in the study. The mean age of the participants was 54.31±13.16 years old, and the post-injury time was 6.20±5.69 years. Most participants were male (80%), paraplegic (67%) and ASIA D (89%). There were 56 participants who walked with a walking device and 41 who did not.

Incidence of fall and consequences

A total of 39 (40%) participants reported at least one fall during the 6-month follow up ("fallers"), while 12 (30%) fell once ("single fall") and 27 (70%) fell twice or more ("multiple fall"). AAD group and Non AAD group experienced multiple fall 18 and 9 persons. The fall incidences among the ADD and non-ADD using participants were 46% (Figure 1) and 32% (Figure 2), respectively. Furthermore, participants in the AAD group were injured 65% of the time upon falling, and those in the non-AAD group were injured 46% of the time. The consequences of falling were wounds, abrasions, bruises, muscle pain and ligament tears. Participants in the AAD group fell mostly while walking within and near their houses, and falls occurred most frequently in the afternoon. Non-AAD group fell mostly while walking around their houses and at the workplace. These falls occur in the morning or afternoon.

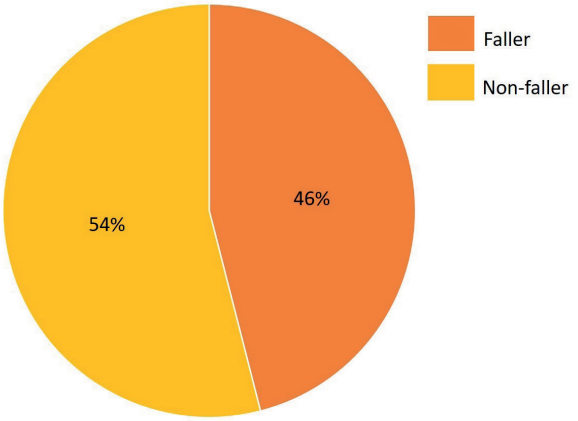

Figure 1 *Incidence of fall in AAD group.*

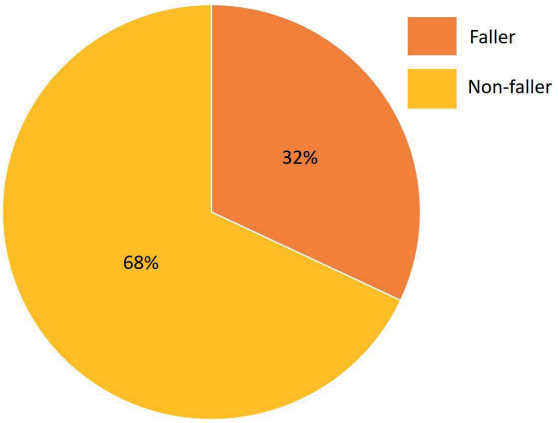

Figure 2 *Incidence of fall in non-AAD group.*

Demographics and factors associated with falls in patients with SCI who walk with an assistive walking device (the AAD group)

Table 1 shows baseline demographics of the AAD group demonstrated that fallers were significantly younger and took a shorter time to complete the TUGT and 10MWT (which they were presented as median) than non-fallers ($p<0.05$). However, there was no significantly difference in FTSST between fallers and non-fallers. Table 2 shows the factors associated with falls in the AAD group. A multivariate logistic regression model used to investigate fallers versus non-fallers among those in the ADD group and revealed that age less than 50 years (aOR=8.21, 95%CI=1.35-50.06, $p=0.023$), moderate to high physical activity (aOR=6.81, 95%CI=1.06-43.83, $p=0.044$) and using crutches (aOR=16.06, 95%CI=1.13-229.02, $p=0.041$) or a cane (aOR=6.72, 95%CI=1.03-43.89, $p=0.047$) significantly increased the risk of falling.

Table 1 Baseline demographics of individuals with spinal cord injury in AAD group (N=56).

Variable	Total (N=56)	Fallers (N=26)	Non-fallers (N=30)
Age: (years)	59 (45.25, 65.5)	46.5 (39.75, 63)	62 (54.75, 69)*
PIT: (years)	4 (3,8)	4 (2.75, 8)	4.5 (2.75, 8.75)
Gender: Male (N) %	46	21 (46)	25 (54)
Level of injury: Paraplegia (N) %	35	20 (57)	15 (43)
Cause: Traumatic (N) %	27	15 (56)	12 (44)
AIS impairment: D (N) %	45	21(47)	24 (53)
TUGT (sec)	29.67 (20.61, 45.13)	23.70 (18.54, 32.16)	40.43 (24.25, 51.94)*
FTSST (sec)	15.32 (12.50, 18.68)	14.31 (11.15, 17.60)	15.48 (13.57, 21.09)
10MWT (m/sec)	0.34 (0.21, 0.51)	0.45 (0.30, 0.61)	0.24 (0.18, 0.44)*

*Note: Continuous data was presented as median (IQR) and compared groups using the Mann-Whitney U test and categorical data using Chi-square test, PIT: post time injury, AIS: American Spinal Injury Association (ASIA) Impairment Scale TUGT: Timed Up and Go Test, 10MWT: 10 Meter Walk Test, FTSST: Five Times Sit to Stand Test, *significant differences of p<0.05.*

Table 2 Factors associated with fall in spinal cord injury who walked with walking device (N=56).

Variable	Total (N=56)	Fallers (N=26)	Non-fallers (N=30)	uOR (95%CI)	*p* value	aOR (95%CI)	*p* value
Gender: N (%)							
Female	10	5 (50)	5 (50)	Ref.		-	-
Male	46	21 (46)	25 (54)	0.84 (0.21-3.30)	0.803		
Age (years): N (%)							
≥50	34	9 (26)	25 (74)	Ref.		Ref.	
<50	22	17 (77)	5 (23)	9.44 (2.69-33.13)	0.001*	8.21 (1.35-50.06)	0.023*
Physical activity: N (%)							
Low	23	2 (9)	21 (91)	Ref.		Ref.	
Moderate-High	33	24 (73)	9 (27)	28.00 (5.43-144.39)	0.001**	6.81 (1.06-43.83)	0.044*
Type of gait aid: N (%)							
Walker	29	6 (21)	23 (79)	Ref.		Ref.	
Crutches	10	9 (90)	1 (10)	34.50 (3.63-328.28)	0.003**	16.06 (1.13-229.02)	0.041*
Cane	17	11 (65)	6 (35)	7.03 (1.84-26.85)	0.004**	6.72 (1.03-43.89)	0.047*
Level of injury: N (%)							
Cervical	21	6 (29)	15 (71)	Ref.		-	-
Thoracic	11	8 (73)	3 (27)	6.67 (1.31-34.03)	0.023*		
Lumbar	24	12 (50)	12 (50)	2.50 (0.72-8.64)	0.147		
Cause: N (%)							
Non-traumatic	29	11 (38)	18 (62)	Ref.		-	-
Traumatic	27	15 (56)	12 (44)	2.05 (0.70-5.95)	0.189		
AIS impairment: N (%)							
C	11	5 (45)	6 (55)	Ref.		-	-
D	45	21 (47)	24 (53)	1.05 (0.28-3.94)	0.942		

Demographics and factors associated with falls in patients with SCI who do not use an assistive waking device (the non-AAD group)

Table 3 shows demographic data of the non-AAD group showed that fallers took significantly longer time to complete the TUGT, FTSST and 10MWT than non-fallers (p<0.05). Table 4 shows the factors associated with falls in the non-AAD group. A multiple variable analysis indicated a significantly longer time to complete the TUGT (aOR=1.38, 95%Cl= 1.04-1.84, p=0.025) and a history of falling (aOR=7.19, 95%Cl=1.31-39.51, p=0.023) significantly increased the risk of fall.

Discussion

The current study found that 39 participants (40%) at least one fall during the 6-month follow-up. These results are consistent with previous studies on ambulatory SCI patients that used prospective fall interviews (34-54%).[7,18] Our study found that fall incidence among those AAD group (46%) was slightly higher than non-AAD group (32%). Similarly, Roman de Mettelinge found that fall incidence in older adults using a walking device (68%) was dramatically higher than in older adults who did not use one (35%).[19] Some evidence has been found that persons with SCI who use an AAD have poorer balance, muscle

Table 3 Baseline demographics of individuals with spinal cord injury in non-AAD group (N=41).

Variable	Total (N=41)	Fallers (N=13)	Non-fallers (N=28)
Age: (years)	56 (52, 60.5)	55 (48.5, 61)	56 (51.25, 60.75)
PIT: (years)	5 (2, 8)	5 (1.5, 14)	4.5 (2, 8)
Gender: Male (N) %	32	12 (38)	20 (62)
Level of injury: Paraplegia (N) %	30	8 (27)	22 (73)
Cause: Traumatic (N) %	23	7 (30)	16 (70)
AIS impairment: D (N) %	41	13 (32)	28(68)
TUGT (sec)	11.56 (9.85, 14.85)	14.40 (11.69, 16.24)	10.85 (9.57, 13.60)*
FTSST (sec)	0.34 (0.21, 0.51)	0.45 (0.30, 0.61)	0.24 (0.18, 0.44)*
10MWT (m/sec)	0.87±0.20	0.77±0.20	0.91±0.19*

*Note: Continuous data was presented as median (IQR) and mean±SD, To compared between groups using the Mann-Whitney U test and independent t-test and Categorical data using Chi-square test, PIT: post time injury, AIS: American Spinal Injury Association (ASIA) Impairment Scale , TUGT: Timed Up and Go Test, 10MWT: 10 Meter Walk Test, FTSST: Five Times Sit to Stand Test, *significant differences of p<0.05*

Table 4 Factors associated with fall in spinal cord injury who walked with walking device (N=41).

Variable	Total (N=41)	Fallers (N=13)	Non-fallers (N=28)	uOR (95%CI)	*p* value	aOR (95%CI)	*p* value
Gender: N (%)							
Female	9	1 (11)	8 (89)	Ref.		-	-
Male	32	12 (38)	20 (62)	4.81 (0.53-42.26)	0.162		
Age (years): N (%)							
≥50	30	7 (23)	23 (77)	Ref.		-	-
<50	11	6 (55)	5 (45)	3.94 (0.92-16.94)	0.065		
Physical activity: N (%)							
Low	31	7 (23)	24 (77)	Ref.		-	-
Mod-High	10	6 (60)	4 (40)	5.14 (1.13-23.51)	0.035*		
Level of injury: N (%)							
Cervical	11	5 (45)	6 (55)	Ref.		-	-
Thoracic	9	2 (22)	7 (78)	0.34 (0.05-2.46)	0.287		
Lumbar	21	6 (29)	15 (71)	0.48 (0.11-2.20)	0.343		
Etiology: N (%)							
Non-traumatic	18	6 (33)	12 (67)	Ref.		-	-
Traumatic	23	7 (30)	16 (70)	2.05 (0.70-5.95)	0.189		
AIS impairment: N (%)							
C	0	-	-	N/A	-	-	-
D	41	13	28				
Fear of falling: N (%)							
No	17	2 (12)	15 (88)	Ref.		-	-
little-Mod	15	7 (47)	8 (53)	6.56 (1.10-39.32)	0.039*		
High	9	4 (44)	5 (56)	6.00 (0.83-43.29)	0.076		
History of fall: N (%)							
No	29	6 (21)	23 (79)	Ref.		Ref.	
Yes	12	7 (58)	5 (42)	5.37 (1.25-23.05)*	0.024*	7.19 (1.31-39.51)	0.023*
TUGT (sec)	11.56 (9.85, 14.85)	14.41 (11.69, 16.24)	10.85 (9.57, 13.60)	1.29 (1.03-1.62)	0.028*	1.38 (1.04-1.84)	0.025*
FTSST (sec)	11.51±3.07	12.47±2.23	11.06±3.6	1.17 (0.93-1.46)	0.183	-	-
10MWT (m/sec)	0.87±0.20	0.77±0.20	0.91±0.19	0.23 (0.01-1.00)*	0.005*	-	-

*Continuous data was presented as median and mean±SD, AIS: American Spinal Injury Association Impairment Scale, TUGT: Timed Up and Go Test, 10MWT: 10 Meter Walk Test, FTSST: Five Times Sit to Stand Test, *Odd ratio is significantly different from reference group for which the value was set at 1.00 (p<0.05)*

strength and walking ability than those who do not.[2] Thus, lower functional ability might increase the risk of fall in ambulatory individuals with SCI.

The current study found that age lower than 50 of SCI patients with AAD group had greater odds of falling than those over 50 years old for 8.21 times. This finding is consistent with a previous study that found SCI patients who fell were generally under 50 years old.[7] Similarly, Matsuda *et al*.[20] found that the occurrence of falls peaked in a middle age group of older adults with disabilities. iSCI who are younger and more active have also been reported to have a greater risk for recurrent falls.[21] Furthermore, the members of the AAD group in the current study who were more physically active were found to be at greater odds of having a fall. In other words, behavioural factors account for younger participants' higher probability of falling: younger participants tend to perform more physical activity, walk long distances, and engage in social activities while paying little attention to their movement.

On the other hand, previous studies have reported that regular physical activity is associated with a reduced risk of poor physical health, which is linked to decreased fall risk in older adults.[22,23] The elderly have poor physical health and functional declined due to aging process while, SCI patient in this study still have neurological deficits and high physical activity could walk with long distance to engage social community. Thus, ambulatory patients with SCI who were high physical activity exposed to risk of fall.

In addition, our study found that SCI patients who use a cane or crutches were at increased odds of falling compared to those who used a walker. Previous research has reported that canes and crutches support less body weight and thus provide less stability than walkers (75-100% of body weight).[24] Furthermore, reliance on a single cane or crutches is associated with walking longer distances than a walker.[25] This may contribute to an increase in fatigue and pain that induces a compensation pattern for insufficient muscle strength and abnormal gait pattern, leading to a higher fall risk.[3,26] Moreover, the use of crutches can cause a compensatory walking pattern and result in more energy consumption, both of which interfere with hip, ankle and walking control strategies.[27-29] These fall findings among SCI patients who use an AAD may imply that they challenge themselves to

attempt a variety of daily activities, but their functional performance may be insufficient (Table 1). Individuals with SCI in this study might use these devices inappropriately without guidance; however, AAD can decrease fall risk if a professional instructs and trains to use them safely and correctly.

In non-AAD group, a history of falling and taking longer to complete the TUGT were associated with higher odds of falling falling (aOR=1.38 for TUGT and 7.19 for history of fall). These findings are similar to those of Jorgensen *et al.*[12] who found that a history of falling was an important predictor for further falls in ambulatory SCI patients (OR=4.2). A history of falling can reflect both intrinsic (muscle weakness, poor balance, poor walking performance) and extrinsic (environmental hazards) factors. [30,31] These consistency with the finding of current study found participants who fell in non-AAD group had poor muscle strength, poor balance control and poor walking speed (Table 2). Extrinsic factors mostly occur in those who fall once, while those who fall multiple times are usually affected by neuromuscular performance, muscle strength and balance.[32,33] The average number of falls in the non-AAD group was also reported as three per person in the current study. These findings reflect that those who had a history of falling in the non-AAD group in this study had musculoskeletal and neurological system changes that caused a high risk for falls.

Loss of balance has also been reported in other studies as a strong factor associated with fall including in ambulatory SCI patients and the elderly.[13,32] Previous studies have reported that individuals who fall have poorer balance than non-fallers.[32,33] In addition, fallers have a problem with mediolateral sway direction interfering with balance.[9,30] The TUGT is a test that can predict fall and has a cut-off point for risk of fall of >13.5 sec.[15] The non-AAD fallers in this study scored an average of 14.40 sec. This implies that non-ADD users still have insufficient balance and abandon walking aids too soon when trying to regain the ability to participate in social activities and improve self-confidence.

The ambulatory SCI patients in both groups had high fall incidence. Especially, individuals who used an ADD appeared to be at a higher risk of falling. Participants in the AAD group who were younger, moderately to highly physically active and relied on a cane or crutches had a higher fall risk. In the non-AAD group, the factors for falls were a history of falling and loss of balance. Fallers who used an AAD had high functional performance (Table 1), which is different from those with other conditions, such as stroke or old age, while fallers in the non-AAD group had low functional performance (Table 2), similar to those other conditions. Therefore, therapists should consider falls and the associated factors in ADD and non-ADD using ambulatory SCI patients separately to provide proper rehabilitation that prevents falls and subsequent injury

There are some limitations of this study such as most of participants in this study were male (80%) paraplegic (67%) and ASIA D (89%). Therefore, the results could not be generalised to the entire population of SCI patients. Therefore, future study should be conducted in other population such as female, tetraplegic and ASIA A to C. In addition, there is a lack of information on drug intake and health conditions that might have led to a fall. These factors should be considered in further studies.

Conclusion

The ambulatory SCI patients in both groups had high fall incidence. Especially, individuals who used an ADD appeared to be at a higher risk of falling. This current study suggest that therapists should consider falls and the associated factors in ADD and non-ADD using ambulatory SCI individuals separately to provide proper rehabilitation that prevents falls and subsequent injury. Thus, therapists should focus on young age groups, select appropriate assistive devices before discharging them from the hospital, and follow up continuously with the AAD group. In non-AAD users, rehabilitation professionals should concern fall history and emphasize balance control even if they walk independently for fall prevention.

Conflicts of interest

The authors declare no conflict of interest.

Ethical approval

The participants gave their informed consent before enrolling in the study. The study was approved by the Khon Kaen University Ethics Committee for Human Research (No. HE611187).

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