

Study of Walking Ability in Patients with Chronic Spinal Cord Injury: A Cross-sectional study

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Abstract

Introduction: Recovery of ambulation is one of the main goals after SCI and has become the target of several pharmacological and rehabilitative approaches. Therefore, evaluating the natural recovery of walking and the prognostic factors influencing this function is mandatory for planning rehabilitation programs.

Objective: To study the walking ability in patients with spinal cord injury using the Ten-meter walk test and Walking Index for Spinal cord injury II (WISCI) scale and to correlate it with respect to the neurological level of injury and the ASIA Impairment Scale.

Method: This is a prospective observational cross-sectional study conducted over a period of 2 years in a tertiary-level hospital in Northern India. Walking ability in patients with chronic spinal cord injury was assessed using the WISCI II scale and a ten-meter walk test. Walking ability was correlated with the neurological level of injury and the AIS category of patients.

Result: Males outnumbered females in the study, with a ratio of 3.6:1. The most common mode of injury was fall from height (56.8%). The majority of patients (60.78%) had an injury at the lower thoracic level, and a maximum number of patients had a severity of ASIA Impairment Scale (AIS) A (74.5%). Patients with injury at lower thoracic and lumbar levels showed better average velocity during the 10m Walk Test (10mWT) and better walking ability on the WISCI II scale. Similarly, patients who had AIS C and AIS D levels of severity exhibited better walking ability.

Conclusion: The study found that patients who had lower thoracic and lumbar levels of injury had the better walking ability. Similar patients with AIS C and AIS D levels had better walking ability than AIS A and AIS B categories. The study also highlights that the neurological level of injury and severity of injury are prognostic predictors of walking ability in patients with traumatic spinal cord injuries

Keywords: ASIA Impairment Scale, Neurological level, Spinal Cord Injury, Walking ability.

INTRODUCTION

Traumatic spinal cord injury (TSCI) is defined by Kirshblum et al. as an impairment or loss of motor and/or sensory function due to damage to the neural elements within the spinal canal caused by an external force [1]. The worldwide prevalence of SCI varies from 236.0 to 1,298 per million [2]. The incidence of SCI among the Asian population ranged from 12.06 to 61.6 per million [3].

Among the various consequences of SCI, the decrease in the ability to walk or move has been reported to be the most difficult to address, followed by decreases in sexual function, bladder control, and the ability to control the bowel, as well as pain [4]. Several outcome measures [5], such as the Functional Independence Measure (FIM), Spinal Cord Injury Measure (SCIM) and

The walking Index for Spinal Cord Injury (WISCI) is used to assess disability in the SCI population.

Rehabilitative measures following spinal cord injury depend on the level of neurological deficit and the extent of damage whether it is complete or incomplete. The rehabilitative measures include the use of orthoses, crutches, walkers, canes and wheelchairs. Recovery of upper extremity strength, lower extremity motor function, sensory recovery and the prognosis for walking after an injury can be predicted based on the standardized physical examination [6]. In general, most of the functional recovery and gain in motor skills occurs during the first 3 months and may reach a plateau by nine months after injury. However, additional recovery may occur up to 12-18 months post-injury. Improved recovery has been demonstrated in patients with incomplete injuries compared to those with complete injuries, whose recovery is usually limited to levels near the neurological level of injury (NLI) [7]. Depending on the neurological motor deficit, mobility is attained either by using a wheelchair or regaining locomotor ability. In the latter case, walking aids and orthotics may be required. Predictors for regaining ambulation after an SCI are the initial motor score (specifically that of the lower extremities), partial sensory sparing, age, and somatosensory evoked potentials. Patients with an incomplete ASIA Impairment Scale (AIS) B or C SCI typically exhibit an extensive impairment at the beginning. However, AIS B and C have a good prognosis for regaining walking function [8]. Various measures are available for the assessment of walking ability in patients with SCI, which can be classified into timed and categorical measures. Timed walking measures consist of either a timed walk over a predetermined distance which can be used to calculate walking speed or a distance walked over a predetermined time. Categorical walking measures involve the use of ordinal scales to distinguish between different levels of walking ability. Categorical walking measures have the advantage of capturing both walkers and non-walkers and the transition between these states. In addition, unlike timed measures, they do not have a minimum distance or time required to complete the test [9]. Timed walking speed is likely the most well-known and commonly used measure of walking ability. In fact, walking speed has been described as the most valid means of assessing functional walking performance and is considered by some to be the criterion standard of walking ability in SCI [10,11].

Both the SCI Rehabilitation Evidence (SCIRE) working group [9] and the International collaboration for the Cure of SCI Paralysis (ICCP) [12] in their study of systemic reviews on existing SCI walking measures and concluded that no one measure is sufficient but recommend using multiple measures including both timed measures such as the Ten-meter Walk Test (10mWT) as well as categorical measures such as the Walking Index for Spinal Cord Injury-Version Two (WISCI-II) SCI walking measures

AIMS AND OBJECTIVES

The aim of the present study was to assess walking ability in chronic spinal cord injury patients using the Ten-meter walk test (10mWT) and WISCI II scale and to correlate walking ability with respect to the Neurological level of injury and severity of injury in terms of AIS categories.

MATERIALS AND METHODS

This prospective observational, cross-sectional study was conducted in the outpatient department of Physical Medicine and Rehabilitation (PMR) of VMCC and Safdarjung Hospital, from September 2016 to April 2018. A total of 51 diagnosed traumatic and non-traumatic spinal cord injury patients were enrolled in the study after taking written consent and appropriate ethical clearance (IEC/VMCC/SJH/Thesis/July/2016/1074). Patients belonging to

all AIS grades, who completed six months from the date of injury were included in the study. However, the subjects who had sole pressure ulcers, upper or lower extremity fractures, cognitive impairment and consistent traumatic brain injury were excluded from the study. Parameters

The following parameters were used to assess the walking ability of patients with SCI:

1). Ten-meter walking test (10 MWT):

- a). Average self-selected velocity
- b). Average fast velocity

2). Walking Index for Spinal cord injury II (WISCI)

Walking ability was then correlated with the Neurological level of injury and ASIA Impairment Scale (AIS) categories.

STATISTICAL ANALYSIS

Categorical variables were presented in number and percentage (%) and continuous variables were presented as mean \pm SD and median. The data was entered in MS EXCEL spreadsheet and analysis was done using Statistical Package for Social Sciences (SPSS) version 21.0.

RESULTS

In this study, most of the patients 30 out of 51 (58.82%) were in the age group of 21-40 years. Males 40 (78.43 %) outnumbered 11 (21.57%), females, with a male-to-female ratio of 3.6:1. The most common mechanism of injury observed was falling from height (29 of 51; 56.86%) with the majority having a fall from a tree followed by road traffic accident (18 of 51; 35.29%). Patients were classified based on the Neurological level of spinal cord injury and observed that the majority 31 of 51 patients (60.78%) had an injury at a lower thoracic level (D-7 to D -12), followed by 14 of 51 (27.45%) at the lumbar level. Cervical and upper thoracic accounted for 3 patients each (5.88% each).

Among lower thoracic vertebral levels, D12 was the most common site of injury 13 (27.45%) followed by D11 level - 7 (13.73%) and D10 level with a frequency of 5 (9.80%). Similarly, within the lumbar vertebral levels, the L1 level was the most common with a frequency of 7 (13.73%) followed by L3 and L2 levels with a frequency of 4 (7.84%) and 3 (5.88%) respectively. The study population was classified into 4 categories based on the American Spinal Injury Association Impairment Scale (AIS) – A, B, C and D. AIS A represents complete motor and sensory loss below the neurological level of injury. 38 of our 51 patients were AIS A category (74.51 %). AIS B represented complete motor loss along with incomplete sensory loss, it accounted for 8 of the total of 51 patients (15.69%). AIS C and D patient group had incomplete motor and sensory loss below the neurological level of injury. 2 patients (3.92%) were in the AIS C category and 3 patients (5.88%) were in the AIS D category. None of the patients belonged to the AIS E category.

The present study classified patients on the basis of their ability to walk either spontaneously or with the help of a walking aid and observed that 29 out of a total of 51 (56.86%) were able to walk while 22 (43.14%) were not able to walk. Out of a total of 51 patients, 2 walked with the support of orthosis (3.92%).

Analysis of walking ability with respect to age (Table 1) was statistically insignificant (p-value = 0.707). Out of 29 walking patients, the majority belonged to the age group of 21-30 years (10; 34.48%). 86.21% (25 of 29) of walking patients were males. The association of walking ability with respect to gender (Table 1) was also found insignificant (p-value 0.173).

The Association of walking ability with respect to the neurological level of injury (Table 2) was found to be statistically significant (p-value 0.021). Among 29 walking patients, 55.17% (16 of 29) had injuries at the lower thoracic levels and 41.38% (12 of 29) had injuries at the lumbar levels. The cervical and upper thoracic level had only 3.45% (1 of 29) walking patients. The study observed that the lower the neurological level of injury better the walking ability.

The Association of walking ability with respect to the ASIA Impairment Scale (AIS) (Table 2) was statistically insignificant (p-value 0.329). We observed that of 29 walkers, 19 (65.52%) belonged to AIS A, 8 (15.69%) belonged to AIS B, 2 (3.92%) belonged to AIS C and 3 (5.88%) belonged to AIS D category. Among the AIS A category, the walking patients had mostly injury at distal lower thoracic and lumbar vertebral levels leading to possession of a good trunk balance which helped them to walk with the aid of orthosis.

Upon analysis of the walking ability with reference to the 10-meter walk test, two parameters were taken into consideration, Average self-selected velocity and Average fast velocity. The walking ability in the 10-meter walk test and WISCI Scale were correlated with the neurological level of injury. The average self-selected velocity (Table: 3) had a statistically significant association the neurological level of injury (p-value 0.004). Average fast velocity (Table: 3) also had a statistically significant association with the neurological level of injury (p-value 0.007). Patients with a lower thoracic and lumbar level of injury performed better in the 10-meter walk test.

The association of the WISCI Scale in patients with respect to neurological levels of injury (Table:4) was statistically significant (p-value 0.0003). The study observed that the mean WISCI Scale in patients with a cervical level of injury was 5.33 with a SD of 9.24 and that in the upper thoracic was zero. The mean WISCI Scale in patients with a lower thoracic level of injury was 4 with SD of 5.18, and that of lumbar level injury was 10.21 with a SD of 5.81. Patients with lower levels of injury showed better WISCI values.

The Average self-selected velocity (Table: 5) in the AIS A category was found to be 0.03 m/s with a standard deviation of 0.04 m/s while in AIS D was found to be 0.26 m/s with a standard deviation of 0.081 m/s. The association was statistically significant (p-value 0.018). The mean of the average fast velocity (Table: 5) inpatient of AIS A group was found to be 0.03 m/s with SD of 0.05 m/s while that in patients of the AIS D category was 0.48 m/s with SD of 0.54 m/s. These findings were statistically significant with a P -value of 0.018. Patients with AIS D category showed better walking performance.

The correlation of the WISCI Scale with respect to categorization based on AIS (Table 6) was statistically significant (p-value of 0.004). The mean WISCI scale of patients belonging to AIS A group was found to be 3.66 with a standard deviation of 4.42 and that of AIS D category was 12 with SD of 10.58. The assessment was done using the WISCI scale also showed better walking performance by patients at the AIS D category.

The study observed that the lower the neurological level, the better the walking ability. Patients showed a progressive increase in walking performance from AIS category A through category D

Table 1: Association of walking ability with respect to Age and Gender (n=51)

Walking ability			p-value
Parameters	Non-walking (n=22)	Walking (n=29)	
1. Age (in years)			
<=20 years	3 (13.64%)	6 (20.69%)	0.707
21-30 years	5 (22.73%)	10 (34.48%)	
31-40 years	8 (36.36%)	7 (24.14%)	
41-50 years	3 (13.64%)	4 (13.79%)	
>50 years	3 (13.64%)	2 (6.90%)	
2. Gender			
Female	7 (31.82%)	4 (13.79%)	0.173
Male	15 (68.18%)	25 (86.21%)	

Table 2: Association of walking ability with respect to Neurological Level of Injury and Severity of injury (based on AIS categories) (n=51)

Walking ability			
1. Neurological Level of Injury			
Parameters	Non-walking (n=22)	Walking (n=29)	p Value
Cervical (n=3)	2 (9.09%)	1 (3.45%)	0.021
Upper thoracic (n=3)	3(13.64%)	0(0.00%)	
Lower thoracic (n=31)	15(68.18%)	16(55.17%)	
Lumbar (n=14)	2 (9.09%)	12(41.38%)	
2. Severity of injury (based on AIS categories)			
A (n=38)	19 (86.36%)	19 (65.52%)	0.329
B (n=8)	2 (9.09%)	6 (20.69%)	
C (n=2)	0 (0.00%)	2 (6.90%)	
D (n=3)	1 (4.55%)	2 (6.90%)	

Table 3: Association of Average self-selected velocity and Average fast velocity during Ten meter walk test with respect to Neurological level of injury

Parameters	Neurological Level of Injury				P value	
	Cervical (n=3)	Upper thoracic (n=3)	Lower thoracic (n=31)	Lumbar (n=14)		
Average Self-selected Velocity (10 MWT)						
Mean ± SD	0.06 ± 0.1	0 ± 0	0.03 ± 0.05	0.12 ± 0.15	0.004	
Median	0	0	0.01	0.07		
Min-Max	0-0.18	0-0	0-0.25	0-0.6		
Inter quartile Range	0 - 0.135	0 - 0	0 - 0.0280	0.032 -0.150		
Average Fast Velocity (10 MWT)						
Mean ± SD	0.12 ± 0.21	0 ± 0	0.04 ± 0.09	0.17 ± 0.27		0.007
Median	0	0	0.01	0.08		
Min-Max	0-0.36	0-0	0-0.45	0-1.07		
Inter quartile Range	0 - 0.270	0 - 0	0 - 0.0322	0.0350 - 0.200		

Table 4: Association of WISCI scale with respect to Neurological Level of Injury

Neurological Level of injury						
WISCI SCALE	II	Cervical (n=3)	Upper thoracic (n=3)	Lower thoracic (n=31)	Lumbar (n=14)	p value
Mean ± SD		5.33 ± 9.24	0 ± 0	4 ± 5.18	10.21 ± 5.81	0.003
Median		0	0	2	9	
Min-Max		0-16	0-0	0-19	0-20	
Inter quartile Range		0 - 12	0 - 0	0 - 8.250	9 - 12	

Q Table 5: Association of Average self-selected velocity and Average fast velocity during Ten-meter walk test with respect to AIS categories

AIS Categories	A (n=38)	B (n=8)	C (n=2)	D (n=3)	p value
Average self selected velocity(10 meter walk test velocity)					

Mean ± SD	0.03 ± 0.04	0.08 ± 0.09	0.2 ± 0.06	0.26 ± 0.31	
Median	0	0.05	0.2	0.18	
Min-Max	0-0.17	0-0.25	0.15-0.24	0-0.6	0.018
Inter quartile Range	0 - 0.0320	0.00700 - 0.140	0.150 - 0.240	0.0450 - 0.495	
Average fast velocity(10 meter walk test velocity)					
Mean ± SD	0.03 ± 0.05	0.12 ± 0.15	0.26 ± 0.07	0.48 ± 0.54	p Value
Median	0.01	0.06	0.26	0.36	
Min-Max	0-0.21	0-0.45	0.21-0.31	0-1.07	
Inter quartile Range	0 - 0.0350	0.00850 - 0.180	0.210 - 0.310	0.0900 - 0.892	0.018

Table 6: Association of WISCI scale with respect to AIS categories

AIS Categories	A (n=38)	B (n=8)	C (n=2)	D (n=3)	P value
WISCI II Scale					
Mean ± SD	3.66 ± 4.42	9 ± 6.14	18 ± 2.83	12 ± 10.58	
Median	1.5	10.5	18	16	
Min-Max	0-15	1-19	16-20	0-20	
Inter quartile Range	0 - 9	3.500 - 12	16 - 20	4 - 19	0.004

DISCUSSION

Out of a total of 51 patients, only 29 were able to walk. Of which the majority (34.48%) belonged to the age group of 21 to 30 years of age. The study concluded that younger age groups have better walking ability compared to older ones, however, the association was statistically insignificant (p-value = 0.707). Van Hedel and Curt [13] in their study found that functional recovery decreased significantly with increasing age in traumatic complete SCI patients. Studies from Virginia Commonwealth University showed a lower functional outcome on FIM for older individuals following SCI [14] compared to matched controls of younger age. The association of walking ability with respect to gender was statistically insignificant (p value= 0.173). Gender was not found to correlate with motor recovery in patients with complete tetraplegia in the retrospective review by Fisher and colleagues (2005) [15] which was similar to our findings.

The study also observed the role of orthosis for ambulation in patients with SCI. 3.92% (2 of 51) patients were able to walk. It can be concluded that some patients may benefit from the use of orthosis for their walking. A meta-analysis [16] reported walking with orthosis brings some benefits for individuals with SCI, such as improving Bone Mineral Density (BMD); improving the functions of cardiovascular, digestive, and respiratory systems; decreasing muscle spasm and joint contractions.

We observed a statistically significant association between neurological level and walking ability (p-value 0.021). Patients who had lower thoracic and lumbar levels of injury had better walking ability than those of cervical and upper thoracic. Similarly, in the 10-meter walk test,

patients with lower thoracic and lumbar levels of injury had better average fast velocity and self-selected velocity. Assessment of the WISCI scale with the neurological level of injury also observed better walking performance by patients with a lower level of injury than those with higher levels of injury. The association was statistically significant. A study conducted in Australia found that the 40-year survival rate of individuals with spinal cord injury was 47% for tetraplegics and 62% for paraplegics [17]

The association of walking ability with respect to the severity of injury (based on ASIA Impairment Scale) was statistically insignificant (p-value 0.329). We observed that among 29 walking patients, 19 (65.52%) belonged to AIS A, 8 (15.69%) belonged to AIS B, 2 (3.92%) belonged to AIS C and 3 (5.88%) belonged to AIS D category. Among the AIS A category, the walking patients had mostly injury at distal lower thoracic and lumbar vertebral levels leading to possession of a good trunk balance which helped them to walk with the aid of orthosis. The severity of the injury was considered the primary predictor for neurological recovery in multiple studies [15, 18]. The retrospective analysis of the data from the multicenter trial found that level of injury was a strong predictor for marked recovery but was confounded by injury severity [18]

The association of Average self-selected velocity and Average fast velocity (p-value 0.018) in 10 MWT with respect to AIS categories was statistically significant. The mean of the average fast velocity in patients of AIS A group was found to be 0.03 m/s with SD of 0.05 m/s while that in patients of AIS D category was 0.48 m/s with SD of 0.54 m/s. The study concluded that patients showed progressive improvement of average velocity in the 10-meter walk test from AIS A to AIS D.

Correlation of WISCI Scale with respect to categorization based on AIS group was found to have a statistically significant correlation (p-value 0.004). The mean WISCI scale of patients belonging to AIS A group was found to be 3.66 with a SD of 4.42, of AIS B were 9 with SD of 6.14, AIS C group were 18 with SD 2.83 and of AIS D were 12 with SD of 10.58. The lower WISCI Scale of patients in AIS D can be attributed to the injury at the cervical cord level, 2 out of 3 patients in AIS D group leading to decreased in power of key muscle group of lower limb leading to decreased in WISCI Scale. We observed that patients

belonging to AIS C and D categories showed better walking ability when compared with those of AIS A and B categories. A retrospective analysis [19] showed that complete SCI (AIS A) had the least recovery (12.8%) and the best recovery was seen in the motor incomplete group (AIS C and D), 84%) [18]. A study conducted by Vazquez et al. [19] observed that rate of improvement was least in ASIA A patients; whereas incomplete injury patients experienced better recovery, with best improvement was shown by patients in AIS D. Other studies [20] also observed better walking ability for patients of AIS C and AIS D categories compared to A and B categories.

CONCLUSION

The study highlights that the neurological level of injury and severity of injury (based on ASIA Impairment Scale) were strong prognostic predictors for walking ability in patients with spinal cord injury. The patients with SCI who had a lower neurological level of injury (lower thoracic and lumbar) had better walking ability than those with higher levels of injury (cervical and upper thoracic). We also found that patients belonging to AIS C and AIS D had better walking ability than those with AIS A and B levels of injury. Patients showed a progressive improvement in walking ability from AIS A through AIS D. Use of orthosis helped some patients to improve their walking ability. The knowledge of factors which influence the walking ability in patients with chronic SCI will help to predict walking ability and thus assists in planning optimum rehabilitative measures.

CONFLICT OF INTEREST: Nil

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