ORIGINAL ARTICLE

Failures on Obstacle Crossing Task in Independent Ambulatory Patients With Spinal Cord Injury and Associated Factors

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Abstract

Objectives: To primarily explore the proportion and factors relating to failure on an obstacle crossing task in ambulatory participants with incomplete spinal cord injury (iSCI); and to compare balance ability between participants who passed and failed on an obstacle crossing task.

Design: Cross-sectional design.

Setting: Tertiary rehabilitation center.

Participants: Independent ambulatory participants with an iSCI (N=113).

Interventions: Not applicable.

Main Outcome Measures: Primary outcomes were the ability to walk over small obstacles of sizes that are commonly found in homes and communities and factors relating to failure on an obstacle crossing task. The secondary outcome was the data from the timed Up and Go (TUG) test.

Results: Of the participants, 33 failed to walk over an obstacle. Using a walker significantly increased chance of failure, whereas having incomplete paraplegia and American Spinal Injury Association Impairment Scale grade D were the protective factors for the event ($P \leq .01$). The number of failures was also significantly increased because of leg contact with a wide or relative large obstacle (4 and 8cm, $P<.001$). Furthermore, participants who failed required significantly longer time to complete the TUG test than those who passed an obstacle crossing task ($P<.001$).

Conclusions: Apart from the ability of independent walking, rehabilitation professionals may need to emphasize the ability of movement modification of the lower extremities and balance control to improve safety issues for the patients.

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Approximately 70% of patients with incomplete spinal cord injury (iSCI) can become ambulatory after participation in a rehabilitation program.[1] However, most of them can walk nonfunctionally (ie, walk at a slow speed, walk only within the house, walk only a short distance, require assistance from persons or walking devices).[2,3] Amatachaya et al[4] report that 44% of independent ambulatory patients with iSCI fail to walk over small obstacles of sizes that are commonly found in homes and communities (<1−8cm). The inadequate clearance by both the limb and the walking device while

walking over an obstacle can lead to a trip, fall, and subsequent injury. Previous studies indicate that 39% to 75% of independent ambulatory patients with iSCI have experienced at least 1 fall during a 6- to 12-month follow-up period, with most of the falls occurring as a result of stumbling over an obstacle while walking.[2,5,6]

To successfully walk over an obstacle, individuals need to alter their movement kinetics, kinematics, and spatiotemporal characteristics according to the size of obstacles on the floor; that is, increase their step length (for a wide obstacle) or use a flexor strategy to increase foot clearance (for a high obstacle) on a narrow base of support during a single-limb stance phase.[7,8-11] Therefore, the task is more challenging for ability of balance control and mobility than unobstructed walking.[7,8]

Amatachaya[4] found that walking with a walking device posed a risk of failure on an obstacle crossing task 8.5 times higher than not using a walking device (adjusted odds ratio=8.5, P=.07). Consequently, researchers suggest that gait safety of the patients may be threatened when facing obstacles in their environments after discharge. Nonetheless, the researchers recruited a small sample (n=34) and investigated only a few factors associated with failure on an obstacle crossing task, including walking device used and level and stage of spinal cord injury (SCI), without data on the functional impairments of individuals who passed and failed on an obstacle crossing task. As a result, the existing evidence may lack explanatory power to identify individuals with iSCI at a risk for falls. A study that included a larger sample size with the consideration of factors relating to baseline demographics, SCI characteristics, and balance impairments would offer useful information for clinicians to detect early and manage individuals at a risk of falls and subsequent injury after discharge. Therefore, this study primarily evaluated the proportion and factors relating to failure on obstacle crossing of independent ambulatory participants with iSCI, including baseline demographics (age, sex), SCI characteristics (cause, stage, severity, and level of SCI), and walking ability (walking with or without a walking device). Moreover, the study secondarily compared balance ability as measured using the timed Up and Go (TUG) test between participants who passed and failed on an obstacle crossing task. The researchers hypothesized that a large proportion of independent ambulatory participants with iSCI still had trouble walking over small obstacles, particularly those with severe SCI and a low level of walking ability (walking with a walking device). The researchers further hypothesized that participants who failed on an obstacle crossing task had greater balance impairments than those who successfully walked over an obstacle.

Methods

Participants

Participants were independent ambulatory patients with iSCI, aged ≥18 years, from a tertiary rehabilitation center in Thailand. Sample size calculation using the data of adjusted odds ratio of a previous study[4] indicated that the study required 30 to 375 participants. The inclusion criteria were ability to walk independently with or without a walking device for at least 15m (FIM locomotor scores 5–7).[12] The exclusion criteria were having an SCI from a progressive disease, any signs or symptoms that might affect the findings of the study, such as pain in the musculoskeletal system (at rest and with movement) with an intensity of pain of >5 (out of 10) on a numerical rating pain scale,[13] deformity of the spine (ie, scoliosis, kyphosis) and lower extremities (ie, genu recurvatum, genu varus) that could be visually detected, and other disorders that might have negative impacts on ambulatory ability. The experimental protocol of the study was approved by the Khon Kaen University Ethics Committee in Human Research. The eligible participants provided a written informed consent prior to participation in the study.

List of abbreviations:

AIS	American Spinal Injury Association Impairment Scale
iSCI	incomplete spinal cord injury
SCI	spinal cord injury
TUG	timed Up and Go

Apparatus

The study used 6 wooden obstacles (each of them 60cm long and 0.8cm thick) of 6 sizes, including 1cm wide, 4cm wide, 8cm wide, 1cm high, 4cm high, and 8cm high (fig 1), to represent the sizes of obstacles likely found in the home and community.[4,11]

Protocol of the study

Participants were interviewed and assessed for their baseline demographics and SCI characteristics, including cause of injury (traumatic or nontraumatic), stages of injury (subacute [postinjury time<12mo] or chronic [postinjury time≥12mo]),[14] severity of injury according to the criteria of the American Spinal Injury Association Impairment Scale (AIS) grades C or D,[15] level of injury (incomplete tetraplegia or incomplete paraplegia),[16] and baseline walking ability (ability to walk with or without a walking device).

After sufficient rest (blood pressure returned to a baseline level), participants were assessed for their ability to walk over the obstacles along a 10-m walkway in a random order (1 trial/size to minimize learning effects and simulate the condition during a fall, if any; total of 6 trials per participant). Prior to the test, the participants were instructed not to attempt any obstacle that may pose a risk of injury to them. The results were recorded as pass or fail. Pass referred to the ability to successfully complete the task by both the limb and an assistive device without any physical assistance or contacting the obstacle. Fail was recorded when the participants required assistance from the tester or contacted the obstacle with a limb or assistive device.[4,11]

Participants were also evaluated for their balance ability using the TUG test. The test measured the time required to complete the tasks of standing up from a standard armchair, walking at a fast and safe speed for 3m, turning around a traffic cone, walking back, and sitting down on the chair with or without a walking device. Then, the average time required over 3 trials was recorded.[17,18]

During the tests, participants did not wear shoes but wore an orthosis if normally used for daily walking and wore a lightweight safety belt around the waist with a therapist walking or being beside the participants to ensure safety. The sequences of the obstacle crossing test and TUG test were randomly ordered, with a sufficient period of rest between the tests and trials as required or with a Modified Borg Scale score >5 (range, 0–10; 0: no dyspnea; 10: worst possible dyspnea).

Statistical analyses

Descriptive statistics were used to explain baseline demographics, SCI characteristics, and findings of the study. Multiple logistic regression analyses were applied to determine the effects of independent variables, including baseline demographics, SCI characteristics, and baseline walking ability on the ability of walking over obstacles (pass or fail). The results were reported in terms of unadjusted and adjusted odds ratios with corresponding 95% confidence intervals. The findings of participants who passed and failed on an obstacle crossing task were compared using the independent samples t tests for continuous variables and chi-square test for categorical data. The level of statistical significance was set at P<.05.

Results

With the limited number of participants who were eligible based on the criteria of the study, the researchers recruited 113