

ORIGINAL ARTICLE

Reliability and Concurrent Validity of Four Square Step Test Scores in Subjects With Chronic Stroke: A Pilot Study

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Abstract

Objectives: To establish (1) the intrarater and interrater reliability of Four Square Step Test (FSST) times in persons with chronic stroke; (2) the concurrent validity of FSST times with standing balance and functional mobility measures; and (3) the FSST cutoff score for distinguishing the differences in dynamic balance performance of persons with chronic stroke from healthy control adults.

Design: Cross-sectional study.

Setting: University-based rehabilitation center.

Participants: Convenience sample of subjects (N=30) consisting of community-dwelling persons with chronic stroke (n=15) and healthy control adults (n=15).

Interventions: Not applicable.

Main Outcome Measures: FSST scores; balance and functional mobility measured using Berg Balance Scale (BBS) scores; Timed Up & Go (TUG) test scores; and limits of stability (LOS) measured by dynamic posturography.

Results: FSST times showed good intrarater reliability, with intraclass correlation coefficients ranging from .82 to .83 and an interrater reliability >.99. An FSST cutoff score of 11 seconds was able to discriminate between healthy adults older than 50 years and persons with stroke (sensitivity, 73.3%; specificity, 93.3%). FSST times were correlated with LOS scores for directional control in the backward direction ($r=.64$; $P=.01$). FSST was approaching a significant correlation with TUG scores ($r=.59$; $P=.02$) and LOS scores for endpoint excursion in the forward direction ($r=-.58$; $P=.02$). However, there was no correlation with BBS scores.

Conclusion: FSST is an easy-to-administer clinical test with good intrarater and interrater reliability in persons with chronic stroke to assess dynamic standing balance. FSST times of 11 seconds are able to differentiate between persons with chronic stroke and healthy adults older than 50 years. The correlation of FSST times with standing balance and functional mobility measures requires further research with a larger sample size.

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Community-dwelling stroke survivors are often faced with difficulties in changing direction and stepping over obstacles because of impairments in dynamic standing balance.^{1,2} Impaired dynamic standing balance limits the ability to walk safely and increases the risk of falls.^{1,3,4} Studies have shown that 73% of stroke survivors have at least 1 fall in the first 6 months poststroke, and 60% have a fall shortly after being discharged from the hospital.³⁻⁵ Among the community-dwelling stroke survivors, approximately 15% of

the falls occurred during turning, and 36% to 70% occurred during walking because of losing balance and dragging a foot.^{3,6} Improving dynamic standing balance should be emphasized in optimizing gait performance and thereby reducing the risks of falls in community-dwelling stroke survivors. Thus, physiotherapists need a reliable and valid assessment to establish dynamic standing balance in stroke survivors to monitor their progress in rehabilitation.

The Four Square Step Test (FSST) is a dynamic standing balance test that was designed to assess the ability to rapidly cross over obstacles and change direction in a clinical setting.⁷ Assessment of the FSST requires minimal space, equipment, and time. FSST times are measured by the time taken to step over

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4 walking sticks arranged in a cross configuration in a pre-determined sequence (fig 1). The participants are required to complete a round in clockwise direction followed by a reverse order, and finally returning to the starting point. The test has been found to be sensitive for detecting changes in dynamic standing balance over a 2- or 4-week period of stroke rehabilitation.⁸ FSST times of more than 15 seconds have also been found to be able to predict falls in chronic stroke survivors,⁸ and to predict multiple fallers who had 2 or more falls within 6 months in community-dwelling adults older than 65 years.⁷

Excellent interrater reliability (intraclass correlation coefficient [ICC]=.99) and test-retest reliability (ICC=.93–.98) of FSST times have been reported in healthy older adults⁸ and in people with vestibular disorders.⁹ Despite the potential utility of the FSST in stroke rehabilitation, its intrarater and interrater reliabilities have not yet been investigated systematically with people after stroke. Moreover, a strong association has been demonstrated between FSST times and Step Test scores (ICC=.94–.99).⁸ Step Test scores have been shown to have significant correlation with balance ($r=.73$) in subjects with chronic stroke.¹⁰ Therefore, balance may affect the performance of the FSST. However, the correlation between FSST times and balance in persons with stroke has not been investigated. In addition, previous studies have shown that FSST times are capable of discriminating between fallers and nonfallers in community-dwelling older adults,⁷ transtibial amputees,¹¹ people with vestibular dysfunction,⁹ people with multiple sclerosis,¹² and in people with stroke.¹³ However, no studies have used the FSST to compare the dynamic standing balance performance of persons with chronic stroke with that of healthy older adults.

The objectives of the present study were to (1) investigate the intrarater and interrater reliability of the FSST in subjects with chronic stroke; (2) investigate the concurrent validity of FSST times with limits of stability (LOS), the Berg Balance Scale (BBS), and the Timed Up & Go (TUG) test; and (3) determine the FSST cutoff score for differentiating the differences in dynamic standing balance between persons with stroke and healthy control adults. We hypothesized that the intrarater and interrater reliability for the FSST would be good, and that FSST times would be significantly correlated with LOS, BBS, and TUG in persons with chronic stroke.

Methods

Participants

Two groups of subjects were recruited through convenience sampling. Fifteen community-dwelling persons with chronic

stroke were recruited from local self-help groups. Participants with stroke were recruited if they were at least 6 months post-stroke, medically stable, older than 50 years, and able to ambulate at least 10m independently with or without aids. Exclusion criteria were any cerebellar involvement or other conditions that might affect muscle strength, balance, or mobility status, or if there was difficulty following instructions. Fifteen independent, community-dwelling adults older than 50 years were recruited from several neighborhood community centers through poster advertisements. These community centers do not provide any medical or rehabilitative services. No fall history was reported from the participants. Subjects were excluded if they had a history of neurologic or musculoskeletal disorders, or had experienced pain in the lower extremities affecting mobility during the previous 3 months as confirmed through subjective questioning.

The ethics committee of the local institution approved the protocol of this cross-sectional study, which was conducted in accordance with the Helsinki Declaration of 1975 as revised in 1983. Informed consent was obtained from all subjects before the study.

Outcome measures

Four Square Step Test

During the FSST,⁷ subjects were required to step in a pre-determined sequence over four 90-cm-long walking sticks, placed in a cross configuration on the ground. The participant's starting position is in square 1 facing square 2 (see fig 1). Then, the participant starts by stepping forward, to the right, backward, and to the left into each quadrant in the clockwise direction, followed by the reverse sequence in the counterclockwise direction (ie, the sequence 2, 3, 4, 1, 4, 3, 2, 1 in fig 1). Both feet must make contact in each quadrant. The participant was instructed to complete the sequence as fast as possible without touching the sticks. The time taken to complete the sequence was recorded. The trial was considered a failure and repeated if the sequence was not completed correctly, the subject lost his/her balance, or a foot touched a cane. Trials are only repeated to a maximum of twice if the participant fails during the second and third trials. Each participant performed 3 trials with a 1-minute rest between trials to avoid possible fatigue. Test scores were taken from the mean of trial 2 and trial 3.

Timed Up & Go test

The TUG test was used to measure functional mobility.¹⁴ It has shown good reliability (ICC=.95) with stroke patients.¹⁵ Participants were required to stand up from a chair with armrests, walk 3m, turn around, return to the chair, and sit down. The time taken to complete this task was measured in seconds with a stopwatch. Each participant undergoes 3 trials, and the mean of the second and third trials was calculated.

Berg Balance Scale

The BBS was used to assess each subject's ability to maintain stability during functional tasks.¹⁶ It is known to have good reliability (ICC=.97–.98) with stroke survivors. The BBS includes 14 tasks, and each task is rated on a 5-point scale (0–4) with a maximum score of 56.

Laboratory balance performance: LOS test

The SMART Balance Master^a apparatus was used to assess postural stability by quantifying the LOS parameters when participants transfer their body weight as far as possible toward

List of abbreviations:

AP	anterior-posterior
AUC	area under the curve
BBS	Berg Balance Scale
COP	center of pressure
DC	directional control
EPE	endpoint excursion
FSST	Four Square Step Test
ICC	intraclass correlation coefficient
LOS	limits of stability
ML	medial-lateral
ROC	receiver operating characteristic
TUG	Timed Up & Go

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