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Abstract

Purpose: The ability to maintain standing balance with a moving base of support and while making rapid postural adjustments is important for independence in various functional activities. Clinical tests and measures have not addressed this ability in children with disability. This pilot study examined the feasibility and reliability of the Four Square Step Test (FSST) as a test of dynamic balance in children with cerebral palsy (CP). Method: Four children with CP (Gross Motor Function Classification Scale levels I-II) were tested on the FSST by 3 assessors on the first occasion (interrater reliability) and repeat-tested by 1 assessor after 2 weeks (test-retest reliability). Six children with typical development (TD) were tested on a separate occasion to explore any between-group difference in performance. Results: The FSST was easy to setup, required no specialized equipment, could be completed in 5 minutes, and might be carried out by clinicians with limited experience in pediatric therapy. It demonstrated excellent interrater reliability (ICC = 0.832) and test-retest reliability (ICC = 0.979) in children with CP. Compared with FSST times for children with TD (mean = 9.12 ± 2.67 seconds), times for children with CP (mean = 18.38 ± 9.02 seconds) were significantly slower ($p = 0.019$, Mann-Whitney U = -2.345). Conclusions and Recommendations: The pilot study provides initial evidence on the potential usefulness of the FSST as a test of dynamic standing balance in children with CP. This warrants further investigation of the clinimetric properties of the FSST using an adequate sample size.

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Reliability and Feasibility of the Four Square Step Test for Use in Children with Cerebral Palsy: A Pilot Study

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ABSTRACT

Purpose: The ability to maintain standing balance with a moving base of support and while making rapid postural adjustments is important for independence in various functional activities. Clinical tests and measures have not addressed this ability in children with disability. This pilot study examined the feasibility and reliability of the Four Square Step Test (FSST) as a test of dynamic balance in children with cerebral palsy (CP). **Method:** Four children with CP (Gross Motor Function Classification Scale levels I-II) were tested on the FSST by 3 assessors on the first occasion (interrater reliability) and repeat-tested by 1 assessor after 2 weeks (test-retest reliability). Six children with typical development (TD) were tested on a separate occasion to explore any between-group difference in performance. **Results:** The FSST was easy to setup, required no specialized equipment, could be completed in 5 minutes, and might be carried out by clinicians with limited experience in pediatric therapy. It demonstrated excellent interrater reliability (ICC = 0.832) and test-retest reliability (ICC = 0.979) in children with CP. Compared with FSST times for children with TD (mean = 9.12 ± 2.67 seconds), times for children with CP (mean = 18.38 ± 9.02 seconds) were significantly slower ($p = 0.019$, *Mann-Whitney U* = -2.345). **Conclusions and Recommendations:** The pilot study provides initial evidence on the potential usefulness of the FSST as a test of dynamic standing balance in children with CP. This warrants further investigation of the clinimetric properties of the FSST using an adequate sample size.

INTRODUCTION

Problems in standing balance, whether in steady stance or when rapidly shifting weight, have been documented in children with cerebral palsy (CP).^{1,2} Impairments such as postural deviations, greater co-activation of agonist and antagonist muscles during walking, delayed and disorganized timing of muscle recruitment, tone abnormalities, and difficulty increasing the amplitude of muscle response to increasing threats to balance contribute to impaired balance in children with CP.³ Poor balance causes difficulties in children's functional activities because good balance (i.e. the ability to anticipate, avoid and recover from either internally-generated or externally-generated instability) is integral to gross motor development.⁴⁻⁵

Balance is affected by the task as well as the environment in which the task is performed; thus, balance assessment should consider task and environment requirements.⁶ For example, tasks performed over a small or with a moving base of support (BOS) pose greater demands on balance than those done on a larger or non-moving BOS. Environmental constraints, such as the presence of physical obstacles and time constraints, likewise shape the patterns of stepping and eye-head movement used

to maintain stability in standing. Although several clinical tests of standing balance have been validated for children with CP, most involve testing on a stationary base of support and are limited in assessing balance in conditions with task and environmental constraints.⁷ No test has examined important balance maneuvers for daily life like stepping backward and sideward and over obstacles, and making rapid changes in direction in this population.

The Four Square Step Test (FSST) measures rapid stepping in different directions and over low obstacles.⁸ It is highly practical to administer, with little time, equipment and space requirements. FSST measurements have been shown to be reliable and valid in non-disabled and disabled adult groups.⁸⁻¹³ Also, scores on the FSST have discriminated between non-disabled groups and people with stroke.¹⁰ Measurement properties, however, are population-specific and thus need to be established for other client groups.¹⁴ This pilot study explored the feasibility and interrater and test-retest reliability of the FSST on children with CP. Test performance of children with CP was also compared with controls.

METHOD

The pilot study was approved by the ethics review committee of the University of the Philippines Manila - College of Allied Medical Professions.

Participants

Ten children (4 with CP and 6 controls) participated. The children's parents provided written consent while the children gave verbal assent to commence participation in the study. Inclusion criteria for the children with CP were age between 7 to 12 years, medical diagnosis of CP, Gross Motor Function Classification System (GMFCS) levels I-III, and ability to understand at least 2-step commands.¹⁵ Patients were conveniently sampled from an outpatient pediatric clinic in the Philippines. Excluded were children with severe visual, vestibular or cognitive impairment, or behavioral problems. Controls were typically-developing children who were within the age range of 7 to 12 years.

Test Protocol

Testing sessions were two weeks apart for children with CP. On the first session, 3 trained assessors (1 physical therapist with 2 years of pediatric therapy experience and 2 final-year physical therapy students) administered the FSST independently for interrater reliability. After two weeks, the participants were tested again by the physical therapist for test-retest reliability. Scores from the first session were made unavailable to the assessor on the second session to minimize bias. Children with typical development (TD) were tested on a separate day. Testing conditions, including set up, instructions, and time of the day, were kept similar across all testing sessions. The participants wore comfortable clothing and usual footwear.

The FSST was administered according to the original protocol (see Figure 1).⁸ Four standard canes configured as a cross on the floor created 4 squares. Initially standing in square 1 and facing square 2, participants stepped into each square in the sequence 2, 3, 4, 1, 4, 3, 2, 1. The test required stepping forward, backward and sideward. Participants completed the step sequence as fast as possible without touching the canes and with both feet making contact with each square. A digital stopwatch was used to quantify completion time. Time started when one foot contacted the floor on square 2 and ended when the last foot touched the floor on square 1. In this study, colored paper markers were placed on the corners of the squares to cue the step sequence. If the child showed difficulty following the number sequence, the colors of the markers were used to instruct the sequence: yellow-green-blue-black-blue-green-yellow-black. The testing surface comprised non-skid rubber mats and was set up away from obstructions.

Each assessor provided a test demonstration and 1 practice trial for each participant. Instructions were given in either English or Filipino, depending on the language used by the child. The participants faced forward in the same direction during testing. If the child could not follow the instructions, cues such as pointing to the appropriate square or tapping the shoulder, hip or thigh were provided. When a participant performed the test sequence incorrectly, lost balance, or touched a cane with a foot, the trial was stopped and repeated. Participants rested between trials to avoid fatigue. The best time of 2 successful trials was utilized. The number of attempts required by each participant before successful completion was recorded.

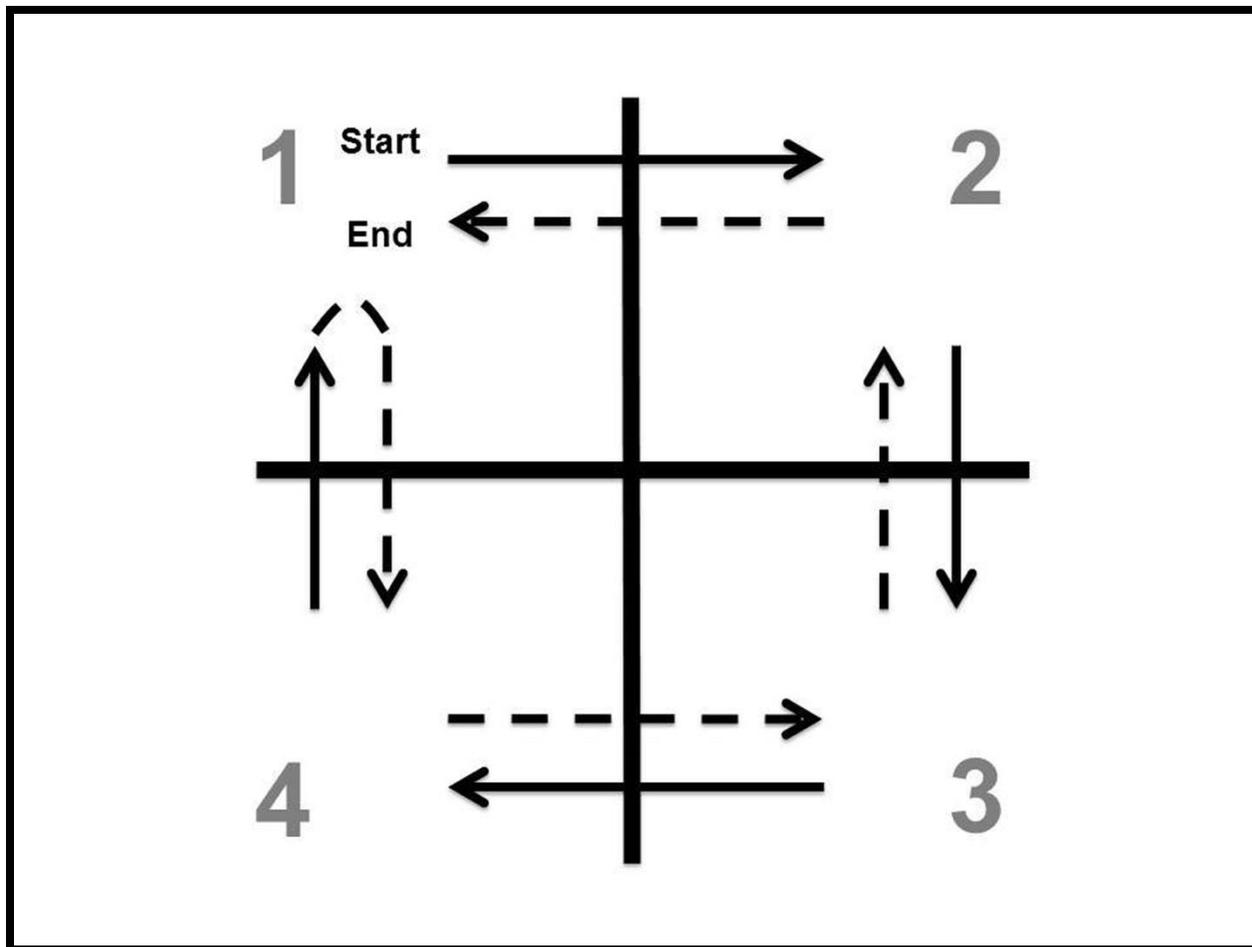


Figure 1 FSST set up and stepping sequence

Data Analysis

Intraclass correlation coefficients (ICC) were calculated for interrater and test-retest reliability. Reliability was excellent if the ICC was ≥ 0.80 ; adequate if it ranged 0.60 to 0.79; and poor if it was < 0.60 .¹⁶ Potential between-group difference in test performance was examined using the Mann Whitney U test. The alpha level was set at .05.

RESULTS

Participant characteristics are summarized in Table 1. Two had CP of the diplegic type, 1 of the athetoid type and 1 of the spastic (quadriplegia) type. None was dependent on an assistive mobility device (GMFCS levels I [Walks indoors and outdoors, and climb stairs without limitations. Performs gross motor skills including running and jumping but speed, balance, and coordination are reduced.] and II [Walks indoors and outdoors, and climb stairs holding onto a railing but experiences limitations walking on uneven surfaces and inclines, and walking in crowds or confined spaces. Have at best only minimal ability to perform gross motor skills such as running and jumping.]).¹⁵ All were undergoing physical therapy, occupational therapy, speech therapy, or a combination of therapies.

Table 1. Group characteristics of children with CP and TD

	Children with CP (n = 4)	Children with TD (n = 6)
Age (yr)	9 ± 2	9 ± 2
Height (cm)	121 ± 6	131 ± 17
Weight (kg)	23 ± 7	26 ± 10
Gender (male/female)	1/3	3/3
GMFCS level		
Level I	3	NA
Level II	1	NA

CP = cerebral palsy, TD = typical development, GMFCS = Gross Motor Function Classification System, NA = not applicable

FSST mean scores and reliability estimates are reported in Table 2. Children with CP required longer test completion times on both test occasions compared with children with TD ($p = 0.019$, *Mann-Whitney U* = -2.345), by 9.26s on session 1 and 9.57s on session 2. The 3 participants with GMFCS level I performed worse than children with TD by 6.14s but better than the participant with GMFCS level II by 13.65s. Testing times recorded independently by the assessors showed excellent interrater reliability (ICC = .832; 95% confidence interval, .395 to .987). Repeated measurement by 1 assessor demonstrated excellent test-retest reliability (ICC = .979; 95% confidence interval, .805 to .999).

Table 2. Interrater and test-retest reliability (ICC, p) in children with CP and mean scores for children with CP and TD

	Children with CP (n = 4)	Children with TD (n = 6)
Mean scores (s)		
Session 1	18.38 ± 9.02	9.12 ± 2.67
Session 2	18.69 ± 7.13	
Interrater reliability	.832, .003	
Test-retest reliability	.979, <.001	

CP = cerebral palsy, TD = typical development

DISCUSSION

This study provides initial evidence for the potential of the FSST as a feasible and reliable tool for assessing dynamic balance in children with CP. The test was set up and administered in 5 to 10 minutes with little required equipment and space. Training of assessors comprised watching a videotaped test administration and several simulations led by the principal investigator in one session. Issues encountered by the children with CP included difficulty in facing in the same direction, observing the correct stepping sequence, clearing the canes, and placing both feet on the square before moving onto the next. Visual and tactile cues were helpful to the participants and close supervision by 1 assessor promoted safety. All participants required 2 to 3 attempts before successfully completing the test trials. This finding points to the need for more practice trials when using this test. Moreover, it highlights that the FSST requires specific minimum cognitive and physical abilities to be successfully completed.^{8,10} In this study, cognitive ability of the participants was not formally assessed. Also, no children at GMFCS level III participated. Thus the feasibility of the FSST for specific cognitive levels and lower motor abilities needs to be explored.

Excellent interrater and test-retest reliability estimates were consistent with those reported for adult client groups.⁸⁻¹³ Given the assessors' limited experience in clinical practice and using the test, these estimates support the potential utility of the FSST for use by "average" service providers. The excellent test-retest reliability estimate also suggests that the FSST may have potential for longitudinal outcomes assessment for children with CP. Differences in scores across participants with different motor abilities are consistent with the result of a recent study on adults with chronic stroke.¹⁰ This finding suggests the FSST's potential to discriminate among different balance abilities. The FSST may provide a means of identifying the need for further balance training in patients with mild disability or those who have become relatively functional but remain unable to participate in more balance-challenging activities in settings like the school or play in the outdoor environment. These findings however must be viewed with caution given the small sample sizes utilized for both the CP and TD groups in this pilot investigation.

CONCLUSION

Although clearly limited by its small sample size, this pilot study is the first to provide initial evidence for the potential reliability and feasibility of the FSST for use on children with CP. The FSST appears to be a highly practical clinical tool for measuring dynamic balance dimensions not covered yet by existing clinical tests and measures. The positive preliminary findings despite the sample size provide an impetus for further, adequately-powered research to clarify the reliability and feasibility of the FSST in this client population.

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