

ORIGINAL ARTICLE

The Reliability and Validity of the Four Square Step Test for People With Balance Deficits Secondary to a Vestibular Disorder

Susan L. Whitney, PhD, PT, NCS, ATC, Gregory F. Marchetti, PhD, PT, Laura O. Morris, PT, NCS, Patrick J. Sparto, PhD, PT

ABSTRACT. Whitney SL, Marchetti GF, Morris LO, Sparto PJ. The reliability and validity of the Four Square Step Test for people with balance deficits secondary to a vestibular disorder. *Arch Phys Med Rehabil* 2007;88:99-104.

Objective: To determine the reliability and validity of the Four Square Step Test (FSST) for use in people with balance deficits secondary to vestibular disorders, who frequently report falling and have difficulty with changes of direction.

Design: Cross-sectional descriptive study.

Setting: Outpatient clinic.

Participants: Thirty-two people with balance deficits secondary to vestibular disorders (mean age, 63.7 ± 17.8 y) who were currently enrolled in a vestibular physical therapy program agreed to participate.

Interventions: Participants performed the FSST, the Timed Up & Go (TUG) test, an 11-m walk test during which walking speed was recorded, and the Dynamic Gait Index (DGI) and completed the Dizziness Handicap Inventory (DHI) and the Activities-Specific Balance Confidence (ABC) Scale.

Main Outcome Measures: The main outcome measures were the FSST time, TUG results, DGI score, gait velocity, and DHI and ABC scores. Number of fall risk factors, as determined by published scores for people at risk for falling on the TUG test and gait speed, and number of falls were compared with FSST scores.

Results: The FSST has good reliability (intraclass correlation coefficient, model 3,1: .93; 95% confidence interval, .86–.96) and had good correlations with the other gait measures (correlation coefficients for the TUG, .69; gait speed, .65; DGI, -.51) and poor correlations with the DHI and the ABC (DHI, -.13; ABC, -.12). Multivariate linear regression showed that 51.5% of FSST performance was explained by TUG score and gait speed. The mean FSST time differed significantly between groups with 0 ($n=12$), 1 ($n=12$), or 2 to 3 ($n=8$) risk factors for falls (analysis of variance, $F=10.02$; $P<.01$). A cutoff score of greater than 12 seconds on the FSST was associated

with a sensitivity of 80% and specificity of 92% for the identification of subjects with 1 or more risk factors for falls.

Conclusions: The FSST is a reliable and valid tool for measuring the ability to perform multidirectional movements in people with balance deficits secondary to vestibular disorders.

Key Words: Balance; Rehabilitation; Reliability and validity.

© 2007 by the American Congress of Rehabilitation Medicine and the American Academy of Physical Medicine and Rehabilitation

THERE IS A GROWING body of literature that suggests that people with vestibular disorders fall frequently, regardless of age.^{1,2} Falls in older adults and people with vestibular and balance disorders have significant consequences.³⁻⁷ Fear of falling can become incapacitating and predisposes people who perceive themselves at risk for falling to inactivity,⁸ which itself can lead to problems of debilitation, increased handicap, and disability.

The development of tools that can help to better identify balance deficits and risk of falling is critical for people with balance disorders. The Four Square Step Test (FSST) has been validated as a balance test for identifying fall risk in older adults.⁹ It incorporates stepping backward, forward, and sideways quickly, which have been reported as being difficult for people with vestibular disorders.¹⁰ It is common practice for physical therapists to have patients perform exercises that contain components of the FSST—that is, walking or stepping in place and changing directions¹⁰—yet rarely have therapists attempted to quantify sideward and backward movements.

If the FSST proves valuable for identifying multidirectional step instability in people with balance and/or vestibular dysfunction, it will help physical therapists and physicians identify another limitation of postural control that may not be captured by traditional clinical balance measures. For example, the FSST might be used by physicians to determine if a person should be referred to physical therapy for balance and/or a falls prevention intervention. The purpose of this cross-sectional study was to determine if the FSST is a reliable and valid measure for determining multidirectional step instability in people with balance and/or vestibular dysfunction. Concurrent validity of the FSST was established by comparing FSST performance with gait velocity, the Timed Up & Go (TUG) test¹¹ results, the Dynamic Gait Index (DGI),¹² the Dizziness Handicap Inventory (DHI),¹³ and the Activities-Specific Balance Confidence (ABC) Scale.¹⁴

METHODS

Patients presenting to the balance and vestibular clinic were asked to sign informed consent to participate in the Four Square Step protocol that had been approved by the University of Pittsburgh Biomedical institutional review board. Thirty-two patients participated in the study (mean age, 63.7 ± 17.8 y;

From the Department of Physical Therapy, University of Pittsburgh School of Health and Rehabilitation Sciences, Pittsburgh, PA (Whitney, Sparto); Department of Otolaryngology, University of Pittsburgh School of Medicine, Pittsburgh, PA (Whitney, Marchetti, Sparto); Department of Physical Therapy, Rangos School of Health Professions, Duquesne University, Pittsburgh, PA (Marchetti); and Centers for Rehab Services, University of Pittsburgh Medical Center, Pittsburgh, PA (Whitney, Morris, Sparto).

Presented in part to the Combined Sections of the American Physical Therapy Association, February 6, 2004, Nashville, TN.

Supported in part by the National Institutes of Health (grant no. DC05384).

No commercial party having a direct financial interest in the results of the research supporting this article has or will confer a benefit upon the author(s) or upon any organization with which the author(s) is/are associated.

Reprint requests to Susan L. Whitney, PhD, PT, NCS, ATC, Dept of Physical Therapy, University of Pittsburgh, 6035 Forbes Tower, Pittsburgh, PA 15260, e-mail: whitney@pitt.edu.

0003-9993/07/8801-1117\$32.00/0

doi:10.1016/j.apmr.2006.10.027

Table 1: Demographic and Clinical Characteristics of Subjects (N=32) Performing the FSST

Characteristic	Values
Mean age \pm SD (y)	63.7 \pm 17.8
Age \geq 65y, n (%)	16 (50)
Diagnostic category, n (%)	
Peripheral	13 (41)
Central	16 (50)
Unspecified	3 (9)
Women, n (%)	17 (53)
Mean length of symptoms \pm SD (mo)	17.5 \pm 36.7
Self-reported falls in the previous 1 month, n (%)	7 (22)
One-time fallers	4 (12.5)
Multiple fallers	3 (9.3)

Abbreviation: SD, standard deviation.

range, 25–91y) (table 1), 17 of whom were women. The average length of symptoms was 17.5 \pm 36.7 months for all subjects. Patients reported the number of falls that they had experienced in the last month. A fall was defined as unintentional loss of balance resulting in the person landing on a lower surface or the ground. Seven of the 32 people had reported a fall within the last month, with 3 of the 7 having experienced more than 1 fall.

Eighty percent of subjects were diagnosed by a neurologist who specializes in balance and vestibular disorders, and the remaining subjects were referred with vestibular disorders from other physicians (primary care physician, neurologists, otolaryngologists). Thirteen patients had a peripheral diagnosis, 16 had a central vestibular diagnosis, and 3 had a combined central and peripheral diagnosis. Eighty percent of subjects had completed an electronystagmography and rotational chair test that aided in making the clinical diagnosis, and the remaining 20% of subjects were referred without vestibular testing results. Six of the patients had abnormal caloric testing results, 10 had abnormal positional testing results, and 12 had an oculomotor abnormality confirmed with vestibular test findings.

Three of the subjects used a straight cane for community ambulation, but none used the cane during testing. Exclusionary criteria included the use of a walker for ambulation or severe arthritis that would limit the ability to stand without pain or discomfort. Thirty-two subjects were able to complete the study. One subject had difficulty understanding the directions but was able to perform the test with multiple repetitions of the verbal instructions plus demonstrations.

Participants performed the FSST, the DGI, and the TUG test, and the velocity of their gait was measured. They also completed 2 questionnaires: the ABC and the DHI. These tests are described in the following sections.

The FSST involves stepping over 4 canes that are laid on the ground at 90° angles to each other (like a “plus” sign) (fig 1). The canes were 90cm in length as first described by Dite and Temple.⁹ The only modification from the original Dite and Temple study⁹ was that T-shaped canes were used, so that there was less risk of people rolling the foot over the cane and injuring the ankles. The T-cane could slide to the right and left but it was impossible to twist the T-cane around its long axis, as one could with a standard cane. Patients were asked to stand in 1 square facing forward with their shoes on. They then rotated clockwise around the “plus sign” by moving forward, to the right, backward, to the left. The patients then reversed their path and moved in a counterclockwise direction. Both feet entered each square. The instructions were, “Try to complete

the sequence as fast as possible without touching the sticks. Both feet must make contact with the floor in each square. If possible, face forward during the entire sequence.”⁹ Interrater reliability was initially reported to be r equal to .99.⁹ With a cutoff score of more than 15 seconds, the test has a sensitivity score of 89%, and for nonmultiple fallers it has a specificity of 85% with a positive predictive value of 86% for detecting a history of falls among community-living adults.⁹

Each subject had 1 practice trial and 2 timed trials. One subject took 1 extra trial and another took 2 extra trials to complete the testing, with all subjects completing the testing within 5 minutes. If a patient touched the cane, lost his/her balance, or did not place both feet in the square, he/she was asked to repeat the trial. In Dite and Temple’s study,⁹ it took less than 5 minutes to perform the testing in older adults.

All patients were tested by 1 of 3 physical therapists. Two of the therapists have greater than 15 years experience with people with balance and vestibular dysfunction, and the remaining physical therapist has over 6 years experience.

Patients completed the 8 walking items of the DGI including walking on level surfaces, with a quick pivot turn, at different speeds, with head movements (pitch and yaw), over and around objects, and up and down steps.¹² Each item was scored on an ordinal scale (range, 0–3) based on established descriptors with a maximum total score of 24. Scores of less than 20 have been related to reported falls in people with vestibular disorders¹⁵ and scores of less than 19 have been related to falls in community-living older people.¹⁶ The DGI has good interrater reliability (κ =.64) in people with peripheral vestibular dysfunction.¹⁷ The DGI was used to describe each patient’s dynamic gait performance.

The time to complete the TUG test was recorded.¹¹ Patients were asked to stand from a chair with armrests, walk 3m, and return to the sitting position in the armchair at their comfortable

Subjects Always Face This Direction

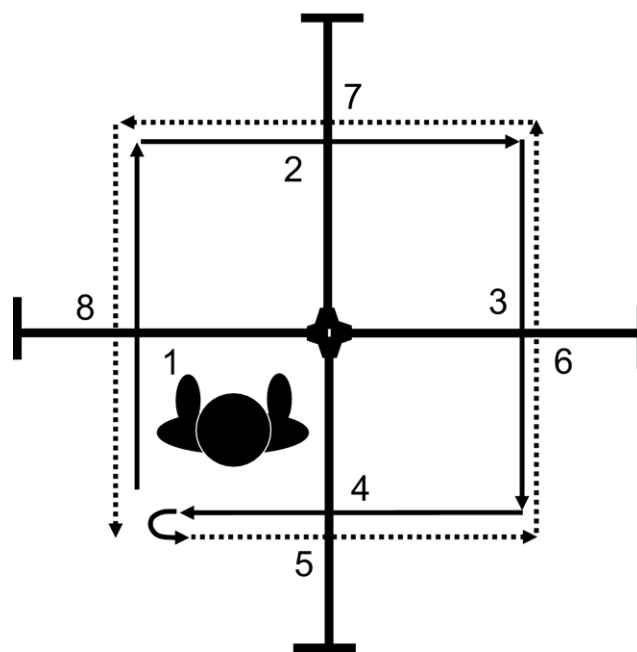


Fig 1. The FSST.

Table 2: Descriptive Means for Concurrent Measures of Gait, Balance, and Perceived Disability for All Subjects

Measures	All Subjects	Age <65 Years	Age ≥65 Years
FSST (s)	13.6±4.3	12.4±4.2	14.8±4.3
TUG (s)	10.3±2.8	9.6±3.2	10.9±2.1
Gait velocity (m/s)	1.01±0.22	1.02±0.23	1.01±0.21
DGI (score range, 0–24)	20.3±3.5	19.9±4.1	20.7±2.9
ABC (%)	62.9±19.6	58.4±17.9	67.4±20.5
DHI (%)	34.7±23.2	42.9±27.1	26.4±15.4

NOTE. Values are mean ± SD. Reliability: excellent consistency was seen across the 2 administrations of the FSST (ICC_{3,1}=.93; 95% confidence interval, .86–.96).

pace. Scores on the TUG test of 11.2 seconds or greater showed the highest sensitivity and specificity for identifying a fall history among people with vestibular dysfunction.¹⁸ Patients were also asked to walk at their normal speed over an 11-m pathway where the middle 6.1m was recorded with a digital stopwatch so that gait speed could be determined.

All subjects completed 2 paper-and-pencil tools: the DHI¹³ and the ABC¹⁴ scale. The DHI is a 25-item questionnaire about perceived handicap from dizziness. DHI scores range from 0 (best score) to 100 (worst score). Scores of more than 60 have been related to reported falls in people with vestibular dysfunction.¹⁹ The ABC is a tool that consists of 16 questions that ask people to rate how confident they are that they could maintain their balance while completing specific tasks.¹⁴ Scores range from 0 to 100, with 100 as the best score. Low scores (under 50) have been related to people who had low levels of physical functioning and also those at risk for falling.^{20,21}

Data Analysis

Test-retest reliability of the 2 administrations of the FSST was determined using intraclass correlation coefficient, model 3,1 (ICC_{3,1}). External construct validity of the ability to change directions quickly was determined by comparing the differences in FSST score between subject groups with fall risk factors using 2-way analysis of variance (ANOVA). Fall risk groups were defined by the number of fall risk factors out of the following 3: self-reported fall in the prior month, TUG score of more than 10 seconds,^{11,18} and gait velocity of less than .80m/s.^{22,23} The Tukey post hoc comparison was used to determine specific group differences. Age was tested as a potential covariate in relation to fall risk factors and FSST performance. Statistical significance was set at *P* less than .05.

Concurrent validity was determined by evaluating the correlational relation between the FSST and other functional and self-reported disability measures described earlier: TUG, gait velocity, DGI, ABC, and DHI. The associations between the FSST and concurrent functional and disability measures were determined with the appropriate correlation coefficient (Pearson or Spearman). A significance level of *P* less than .01 was used to evaluate correlations. To determine the effect of age on the concurrent validity of inferences from FSST measurements, the correlational analyses were performed for age groups created by stratification at less than and greater than or equal to 65 years.

Concurrent validity for measurements of multidirectional postural control with the FSST was described by evaluating the linear relation between the FSST and concurrent measures of the TUG, gait velocity, DGI, ABC, and DHI. Multivariate linear regression analysis was used to identify the significance of the association and the amount of variance (adjusted *R*²) in

FSST score that is potentially explained by the concurrent measures of the TUG, gait velocity, DGI, ABC, and DHI. The best-fitting linear model that explained variance in FSST score was determined using a significance level of *P* less than .05 to evaluate the individual parameter estimates and the full model explaining FSST scores. Subject age was also evaluated as a possible covariate in the linear relation between the FSST and the other study outcome measures.

The ability of measurements taken with the FSST to discriminate between subjects at increased risk for falls was evaluated with a receiver operating characteristic (ROC) curve with analysis of area under the curve (AUC). The sensitivity was plotted against 1 minus specificity for subjects with at least 1 fall risk factor as described earlier. The AUC was tested (at *P*<.05) against an area value of no discrimination (AUC=.50). Maximal sensitivity and specificity for at least 1 of the fall risk factors (number of reported falls in the last month, gait velocity, TUG score) was estimated.

RESULTS

Table 2 presents the descriptive statistics for the FSST, TUG, gait velocity, ABC, and DGI for all subjects and for groups created by stratifying for age at less than and greater than or equal to 65 years. The number of fall risk factors as defined by positive fall history, gait speed, and TUG had a significant effect on FSST score. The mean FSST time differed significantly between groups with 0 (n=12), 1 (n=12), or 2 or 3 (n=8) risk factors for falls (ANOVA, *F*=8.83; *P*<.01). Figure 2 illustrates the mean and 95% confidence interval (CI) for FSST times for 3 groups based on the number of fall risk factors. Post hoc (Tukey) group comparisons showed significant mean differences between the groups with no risk factors and the groups with 1 risk factor (*P*=.01) or 2 or 3 risk factors (*P*<.01). The mean difference between the 1- and 2 or 3-risk factor groups was not significant. Age was not a significant

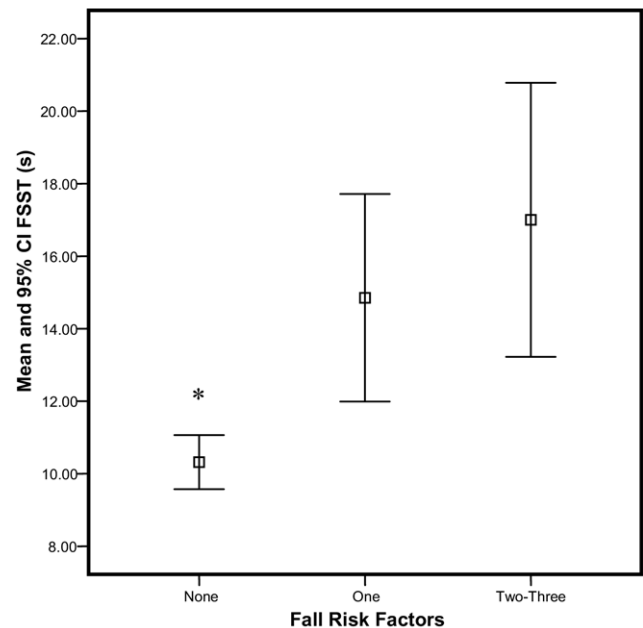


Fig 2. FSST scores (mean and 95% CI) for subjects with none (n=12), 1 (n=12), and 2 or 3 (n=8) fall risk factors as defined by fall history (≥1 falls), TUG test (>10s), and gait speed (<.80m/s). *Post hoc testing showed a significant mean difference (*P*=.01) between no risk factors and those who had either 1 or 2 or 3 risk factors.

Table 3: Correlation Coefficients for the Association Between the FSST, TUG Test, Gait Speed, DGI, ABC Scale, and DHI for All Subjects (N=32)

Measures	FSST	TUG	Gait Speed	DGI*	ABC*	DHI
FSST		.69 [†]	.65 [†]	-.51 [†]	-.12	-.13
TUG	.69 [†]		-.66 [†]	-.56 [†]	-.20	-.00
Gait speed	.65 [†]	-.66 [†]		.82 [†]	.41	-.22
DGI*	-.51 [†]	-.56 [†]	.82 [†]		.39	-.43
ABC*	-.12	-.20	.41	.39		-.72 [†]
DHI*	-.13	-.00	-.22	-.43	-.72 [†]	

*Spearman nonparametric correlation.

[†]Correlations significant at $P < .01$.

covariate in the relation between fall risk and FSST performance (ANOVA, $F=1.98$; $P=.17$).

Excellent consistency was shown across the 2 administrations of the FSST ($ICC_{3,1}=.93$; 95% CI, .86-.96). Table 3 includes the correlation coefficients for the associations between the FSST and concurrent measures of gait, balance, and self-reported disability: TUG, gait speed, DGI, ABC, and DHI.

The FSST showed statistically significant moderate to strong correlations with concurrent measures of gait speed, gait stability (DGI), and gait with transitional movements as measured by the TUG. There were no significant associations with either the ABC or the DHI.

Results of the stepwise linear regression analysis for concurrent validity of the FSST showed that performance on the FSST was significantly associated with TUG and gait speed

Table 4: Correlation Coefficients for Associations Between the FSST and Concurrent Measures of Gait and Balance in Subjects Younger Than 65 Years and Subjects 65 Years and Older

Variable	Subjects <65 Years (n=16)	Subjects ≥65 Years (n=16)
TUG	.90*	.36
Gait speed	-.75 [†]	-.59 [†]
DGI [‡]	-.54 [†]	-.51 [†]
ABC [‡]	-.19	-.27
DHI [‡]	-.12	.06

*Correlation significant at $P < .01$.

[†]Correlation significant at $P < .05$.

[‡]Spearman nonparametric correlation.

($P < .001$). Subject age, DGI, ABC, and DHI were not significant predictors of FSST time (at $P < .05$) in a linear model that also included TUG and gait speed. The TUG was the largest predictor of FSST score, explaining 46.1% of variance in FSST score. A 2-variable model of the TUG and gait speed explained 51.5% of the variance in subjects' FSST performances.

Figure 3 illustrates the ROC curve for values of FSST scores plotted by sensitivity and 1 minus specificity for the identification of subjects with at least 1 fall risk factor: 1 or more falls in the month before testing, TUG score greater than 10 seconds,^{11,18} or gait speed greater than 0.8m/s.^{22,23} The AUC created by the plot of sensitivity versus 1 minus specificity for subjects with 1 or more fall risk factors detected by FSST scores differed significantly from .50 ($AUC=.89$; $P < .01$; 95% CI, 0.78-1.00). A cutoff score on the FSST of 12 seconds generated a sensitivity of 80% and specificity of 92% for the identification of subjects with 1 or more risk factors for falls in this sample of subjects with vestibular disorders.

The correlation coefficients between the FSST and the concurrent measures of gait, balance, and self-reported disability for subjects in groups created by stratifying for age at less than 65 and greater than or equal to 65 years are described in table 4. In both subject groups, FSST score correlated moderately with the DGI scores. Scores for the FSST correlated more strongly ($r = -.75$) with gait speed in younger subjects than in older subjects ($r = -.59$). In younger subjects, the FSST strongly correlated with the TUG ($r = .90$, $P < .01$). The scores on the FSST and TUG were not significantly associated in older subjects.

DISCUSSION

The FSST is a reliable and valid measure that describes the ability of people with balance deficits secondary to a vestibular disorder to change directions quickly. Half of the study patients were community-living adult outpatients over the age of 65 years who presented to a balance center for rehabilitation, similar to Dite and Temple's subjects.⁹ It appears that the FSST may also be helpful in identifying younger people who have difficulty changing directions.

Those 65 years of age and older took longer to complete the FSST (14.8s vs 12.4s) than younger subjects (see table 2). Based on Dite and Temple's work,⁹ 15 seconds was the best score to optimize the sensitivity and specificity of the FSST for identifying multiple fallers. Therefore, the older patients in our study were closer to being at risk for falling as a group than the younger subjects, although only 3 of the 7 people who reported 1 or more falls were over 65 years of age. There were a total of 11 people who obtained an FSST score of greater than 15 seconds.

The younger (<65y) subjects had faster timed scores on the FSST, TUG, and gait velocity but had more impaired scores on

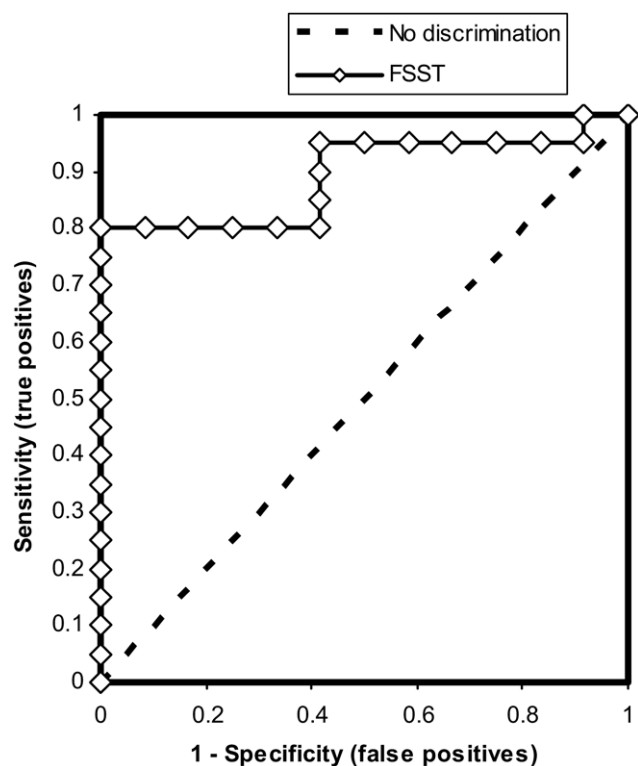


Fig 3. ROC curve for values of the FSST with sensitivity and 1 minus specificity for the identification of subjects (n=20) with at least 1 fall risk factor: 1 or more falls in the month before testing, TUG test score greater than 10 seconds, or gait speed greater than 0.8m/s.

the DGI, ABC, and DHI. The lower (more impaired) scores on the DGI have been reported previously in younger subjects with vestibular disease.^{1,15} Faster TUG scores have previously been reported in younger people compared with older adults.²⁴ It has also been reported that younger people seen in a tertiary balance clinic had greater dizziness handicap and less balance confidence than older people with vestibular dysfunction,² similar to these reported findings.

The reliability between the 2 test administrations of the FSST was .93, indicating that it may not be necessary to perform 2 trials. It would only take a clinician 1 to 2 minutes to explain, perform, and record the FSST score. The FSST could be used as a quick screening tool to assess the ability to step in different directions quickly.

Performance of the ability to change directions quickly was associated with the presence of 3 fall risk factors (reported falls, the TUG, gait speed). Various researchers^{7,25} have previously reported that the risk of falling increases with an increased number of risk factors. The FSST scores of patients who had no reported falls, who walked .80m/s or faster, and who performed the TUG in 10 seconds or less had much faster FSST times than those patients who either had increased time on the TUG and/or had decreased gait velocity.

In a previous study,¹¹ all healthy elderly subjects within an age range of 70 to 84 years performed the TUG in under 10 seconds (mean, 8.5s). The mean TUG score in our study was 10.3 seconds, indicating that as a group, patients who participated in the study did not have significant gait dysfunction, as determined by the TUG test.¹¹ The sample mean TUG scores were similar to the comparison group in the Dite and Temple⁹ (10.0s) and the Podsiadlo and Richardson¹¹ studies (8.5s), suggesting that our overall sample mean was closer to their comparison (control) group than the 1 time- or multiple-faller groups in their studies. Only 22% of subjects in this study reported a fall within the last month.

Wolfson et al²⁶ reported that older adults living in the community ambulate between 1.0 and 1.2m/s. The mean walking speeds of the patients in this study were slower than those older adults living in the community. Nursing home residents who had fallen had mean gait speeds of .53m/s.²⁶ Our patients were closer to the community-living older adults, which seems logical because all of our patients attended an outpatient physical therapy clinic.

Study Limitations

There may have been selection bias by the physical therapists who recruited the subjects, because they may not have asked people who had significant movement impairments to participate in the study. Lajoie and Gallagher²⁰ suggested that scores of 67% and lower on the ABC were related to significant fall risk in community-living older people. Based on this criterion, more than half of the current cohort was at risk for falling, because the median ABC score was 64.

All people who agreed to participate were able to complete the FSST, which is a difficult test because of the total weight transfer required and the demand that subjects complete the test as quickly as possible. Although cognition was not screened, all people were able to sign the consent volitionally, suggesting that the physical therapists had considered the subjects unimpaired or only minimally cognitively impaired. The FSST would not work well with people who have significant cognitive impairment,⁹ because they must remember where to step and one must provide a demonstration and complex instruction for people to complete the task.

The FSST cutoff score for best discrimination of those people with multiple fall risk factors in the present study was

12 seconds. Dite and Temple⁹ reported a cutoff score of 15 seconds for optimal sensitivity and specificity related to reported falls. In our sample, patients had chronic balance and/or vestibular dysfunction. There was greater variability in the scores of patients who participated in the Dite and Temple study,⁹ with one third of their sample consisting of multiple fallers. In this study, only 3 subjects had fallen more than 1 time.

The mean length of symptoms was 17.5 months, indicating that our patients had chronic symptoms. Subjects may have performed well on the FSST because they had over a year to recover from their vestibular disorder, although when length of symptoms was compared with FSST results, there was no relation, suggesting that chronicity had little or no impact on the findings. In a sample of subjects with shorter symptom duration, the findings may have been different.

Making inferences about fall risk based on retrospective reports of falling may limit predictive inferences of future falling. It is difficult to determine if postural adaptations and behavioral characteristics are due to the presence of fall risk factors or patient response to a previous fall.

In addition, FSST scores of half of the subjects were measured by a physical therapist who was blinded to the results of the concurrent outcome measures. It is possible that there could be some bias in the FSST results taken by nonblinded therapists.

The FSST, based on the reported correlations, is a reasonable method to quantify the ability to rapidly shift weight in different directions in people with balance deficits secondary to a vestibular disorder. Dite and Temple⁹ suggest that the FSST might aid in clinicians' understanding of a patient's ability to shift weight quickly to prevent a fall from a trip or slip.

One could complete the FSST without head rotation, because people are instructed to try to look forward throughout the test. Vestibular inputs may be very important because people prepare to turn during gait.²⁷ The FSST may not include enough head movement to be sensitive in identifying dysfunction in people with vestibular disorders.

The DGI attempts to quantify the effects of head movement during gait. One DGI item includes gait while moving the head in the yaw plane. Post hoc analysis showed that people who scored less than "normal" on gait with head turns had significantly slower (3.2s, $P < .02$) FSST scores than those who walked normally with head turns. Future studies should investigate the effect of fast body direction changes that also incorporate head movement in people with balance and/or vestibular disorders.

CONCLUSIONS

The FSST is easy to perform and provides a quantitative measure of the ability to quickly change directions while lifting the feet off the ground. It has been shown to be a reliable and valid measure of postural performance for use with adults with balance deficits secondary to a vestibular disorder. The FSST assesses the ability to change directions quickly, and it takes little time to administer the test.

References

1. Herdman SJ, Blatt P, Schubert MC, Tusa RJ. Falls in patients with vestibular deficits. *Am J Otol* 2000;21:847-51.
2. Whitney SL, Wrisley DM, Marchetti GF, Furman JM. The effect of age on vestibular rehabilitation outcomes. *Laryngoscope* 2002; 112:1785-90.
3. Boulton C, Murphy J, Sloane P, Mor V, Drone C. The relation of dizziness to functional decline. *J Am Geriatr Soc* 1991;39:858-61.

4. Kiel DP, O'Sullivan P, Teno JM, Mor V. Health care utilization and functional status in the aged following a fall. *Med Care* 1991;29:221-8.
5. Pothula VB, Chew F, Lesser TH, Sharma AK. Falls and vestibular impairment. *Clin Otolaryngol Allied Sci* 2004;29:179-82.
6. Bonar SK, Tinetti ME, Speechley M, Cooney LM. Factors associated with short- versus long-term skilled nursing facility placement among community-living hip fracture patients. *J Am Geriatr Soc* 1990;38:1139-44.
7. Tinetti ME, Speechley M, Ginter SF. Risk factors for falls among elderly persons living in the community. *N Engl J Med* 1988;319:1701-7.
8. Legters K. Fear of falling. *Phys Ther* 2002;82:264-72.
9. Dite W, Temple VA. A clinical test of stepping and change of direction to identify multiple falling older adults. *Arch Phys Med Rehabil* 2002;83:1566-71.
10. Whitney SL, Herdman SJ. Physical therapy assessment of vestibular hypofunction. In: Herdman SJ, editor. *Vestibular rehabilitation*. 2nd ed. Philadelphia: FA Davis; 2000. p 354.
11. Podsiadlo D, Richardson S. The timed "Up & Go": a test of basic functional mobility for frail elderly persons. *J Am Geriatr Soc* 1991;39:142-8.
12. Shumway-Cook A, Woollacott M. *Motor control: theory and practical applications*. Baltimore: Williams & Wilkins; 1995.
13. Jacobson GP, Newman CW. The development of the Dizziness Handicap Inventory. *Arch Otolaryngol Head Neck Surg* 1990;116:424-7.
14. Powell LE, Myers AM. The Activities-specific Balance Confidence (ABC) Scale. *J Gerontol A Biol Sci Med Sci* 1995;50:M28-34.
15. Whitney SL, Hudak MT, Marchetti GF. The Dynamic Gait Index relates to self-reported fall history in individuals with vestibular dysfunction. *J Vestib Res* 2000;10:99-105.
16. Shumway-Cook A, Baldwin M, Polissar NL, Gruber W. Predicting the probability for falls in community-dwelling older adults. *Phys Ther* 1997;77:812-9.
17. Wrisley DM, Walker ML, Echternach JL, Strasnick B. Reliability of the Dynamic Gait Index in people with vestibular disorders. *Arch Phys Med Rehabil* 2003;84:1528-33.
18. Whitney SL, Marchetti GF, Schade A, Wrisley DM. The sensitivity and specificity of the Timed "Up & Go" and the Dynamic Gait Index for self-reported falls in persons with vestibular disorders. *J Vestib Res* 2004;14:397-409.
19. Whitney SL, Marchetti GF, Morris LO. Usefulness of the dizziness Handicap Inventory in the screening for benign paroxysmal positional vertigo. *Otol Neurotol* 2005;26:1027-33.
20. Lajoie Y, Gallagher SP. Predicting falls within the elderly community: comparison of postural sway, reaction time, the Berg Balance Scale and the Activities-specific Balance Confidence (ABC) scale for comparing fallers and non-fallers. *Arch Gerontol Geriatr* 2004;38:11-26.
21. Myers AM, Fletcher PC, Myers AH, Sherk W. Discriminative and evaluative properties of the Activities-Specific Balance Confidence (ABC) scale. *J Gerontol A Biol Sci Med Sci* 1998;53:M287-94.
22. Montero-Odasso M, Schapira M, Soriano ER, et al. Gait velocity as a single predictor of adverse events in healthy seniors aged 75 years and older. *J Gerontol A Biol Sci Med Sci* 2005;60:1304-9.
23. Montero-Odasso M, Schapira M, Varela C, et al. Gait velocity in senior people. An easy test for detecting mobility impairment in community elderly. *J Nutr Health Aging* 2004;8:340-3.
24. Thigpen MT, Light KE, Creel GL, Flynn SM. Turning difficulty characteristics of adults aged 65 years or older. *Phys Ther* 2000;80:1174-87.
25. Province MA, Hadley EC, Hornbrook MC, et al. The effects of exercise on falls in elderly patients. A preplanned meta-analysis of the FICSIT Trials. *Frailty and Injuries: Cooperative Studies of Intervention Techniques*. *JAMA* 1995;273:1341-7.
26. Wolfson L, Whipple R, Amerman P, Tobin JN. Gait assessment in the elderly: a gait abnormality rating scale and its relation to falls. *J Gerontol* 1990;45:M12-9.
27. Kennedy PM, Cressman EK, Carlsen AN, Chua R. Assessing vestibular contributions during changes in gait trajectory. *Neuroreport* 2005;16:1097-100.