Clinical Measurement of Sit-to-Stand Performance in People With Balance Disorders: Validity of Data for the Five-Times-Sit-to-Stand Test

Background and Purpose. People with balance disorders are characterized as having difficulty with transitional movements, such as the sit-to-stand movement. A valid and feasible tool is needed to help clinicians quantify the ability of people with balance disorders to perform transitional movements. The purpose of this study was to describe the concurrent and discriminative validity of data obtained with the Five-Times-Sit-to-Stand Test (FTSST). The FTSST was compared with the Activities-specific Balance Confidence Scale (ABC) and the Dynamic Gait Index (DGI). **Subjects and Methods.** Eighty-one subjects without balance disorders and 93 subjects with balance disorders were recruited for the study. Each subject was asked to stand from a 43-cm-high chair 5 times as quickly as possible. The ABC and DGI scores were recorded. **Results.** Subjects with balance disorders performed the FTSST more slowly than subjects without balance disorders. Discriminant analysis demonstrated that the FTSST correctly identified 65% of subjects with balance dysfunction, the ABC identified 80%, and the DGI identified 78%. The ability of the FTSST to identify subjects with balance dysfunction was better for subjects younger than 60 years of age (81%). **Discussion and Conclusion.** The FTSST displays discriminative and concurrent validity properties that make this test potentially useful in clinical decision making, although overall the ABC and the DGI are better than the FTSST at discriminating between subjects with and subjects without balance disorders. [Whitney SL, Wrisley DM, Marchetti GF, et al. Clinical measurement of sit-to-stand performance in people with balance disorders: validity of data for the Five-Times-Sit-to-Stand Test. *Phys Ther*. 2005;85:1034–1045.]

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Susan L Whitney, Diane M Wrisley, Gregory F Marchetti, Michael A Gee, Mark S Redfern, Joseph M Furman

Moving from a sitting position to a standing position is performed daily by active people, and significant functional limitations can occur when the ability to rise from a seat is impaired. Kaya et al[1] reported that older people with bilateral vestibular loss move differently from a sitting position to a standing position than people without such a loss. In addition, Gill-Body et al[2] reported limitations in the ability of people with peripheral vestibular disorders to rise from a chair, walk, and return to the chair. Clinicians could benefit from a feasible and valid measure of the ability of people with balance disorders to move from a sitting position to a standing position.

Csuka and McCarty[3] first described the use of the Sit-to-Stand Test as a measure of lower-extremity strength (force-generating capacity of muscle). The Sit-to-Stand Test is now commonly used to assess lower-extremity strength and balance.[4–9] The ability to stand from a chair is a crucial factor in independence in older adults living in the community.[10,11] The Sit-to-Stand Test has been used for people with arthritis,[9] people with renal disease,[6] people after a stroke,[7,12] and older adults[5,8,13–16] and as an outcome measure of intervention.[17–29] No studies to date have validated the Sit-to-Stand Test in people who have balance disorders by comparing the Five-Times-Sit-to-Stand Test (FTSST) with other balance tools, although the angular and linear control strategies of the sit-to-stand movement have been analyzed in people with bilateral vestibular hypofunction at their self-selected pace.[30]

The Sit-to-Stand Test has been used for multiple purposes, including as an indicator of postural control,[4] fall risk,[10,11] lower-extremity strength,[3,15,17] and proprioception[31] and as a measure of disability.[32,33] The Sit-to-Stand Test has been related to standing and postural control[15] and to falls in older adults.[10,11,34] Chair rise (3 repetitions) has been shown to correlate with gait speed (r=.54),[35] and gait speed has been related to fall risk.[36] Recently, the Sit-to-Stand Test was related to lower-extremity proprioception, postural sway, strength, and visual contrast sensitivity.[4] Slower sit-to-stand times have been shown to be helpful in predicting further disability.[32,33]

Various methods have been used in an attempt to determine how well older adults can rise from a chair.[37] Different authors have suggested timing 1 chair rise with the use of arms[38] or without the use of arms[38,39] or timing 3 chair rises.[35] Other authors[4,10,40–42] have sug-

SL Whitney, PT, PhD, NCS, ATC, is Assistant Professor, Departments of Physical Therapy and Otolaryngology, University of Pittsburgh, Pittsburgh, Pa, and Program Director, Physical Therapy Department, Centers for Rehab Services, University of Pittsburgh Medical Center, Pittsburgh, Pa. Address all correspondence to Dr Whitney at Department of Physical Therapy, University of Pittsburgh, 6035 Forbes Tower, Pittsburgh, PA 15260 (USA) (whitney@pitt.edu).

DM Wrisley, PT, PhD, NCS, is Assistant Professor, Department of Rehabilitation Science, School of Public Health and Health Professions, University at Buffalo, The State University of New York, Buffalo, NY, and Physical Therapist, Centers for Rehab Services, University of Pittsburgh Medical Center.

GF Marchetti, PT, PhD, is Assistant Professor, Department of Physical Therapy, Rangos School of Health Professions, Duquesne University, Pittsburgh, Pa.

MA Gee, BS, is a student, Duke University Medical School, Durham, NC.

MS Redfern, PhD, is Professor, Department of Bioengineering, Otolaryngology, and Physical Therapy, University of Pittsburgh.

JM Furman, MD, PhD, is Professor, Departments of Otolaryngology, Physical Therapy, and Bioengineering, University of Pittsburgh.

Dr Whitney, Dr Wrisley, Dr Marchetti, Dr Redfern, and Dr Furman provided concept/idea/research design. Dr Whitney, Dr Marchetti, Dr Redfern, and Dr Furman provided writing. Dr Whitney and Mr Gee provided data collection, and Dr Whitney, Dr Wrisley, and Dr Marchetti provided data analysis. Dr Whitney provided project management. Dr Whitney, Dr Wrisley, Dr Redfern, and Dr Furman provided fund procurement. Dr Whitney and Dr Furman provided facilities/equipment. Dr Whitney and Dr Marchetti provided clerical support. All authors provided consultation (including review of manuscript before submission).

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gested repeating the chair rise 5 times, and yet additional authors[3,9] have suggested a 10-Times-Sit-to-Stand Test. The number of repetitions completed during a specified time interval (either 10 or 30 seconds) also has been recorded.[6,35,43] There is great disparity in the literature about what is a normal score or a scoring system that should be used for the Sit-to-Stand Test, and there are also great differences in the reported heights of the chairs used.

In addition to the different methods of data collection, various chair heights and foot positions have been reported in the literature. Chair heights of 40 cm,[9] 43 cm,[4,38] 44.5 cm,[3] and 46 cm[43] have been reported. The different heights of the chairs make comparison of results more difficult and affect the results of the studies. In addition, foot positions during the sit-to-stand maneuver affect timed sit-to-stand results,[44] complicating comparison of results across trials.

Other authors[13–16,45] have investigated the biomechanical factors associated with rising from a chair in older adults. Peak whole-body center of mass and peak angular velocities were reported to be lower in failed attempts at sit-to-stand movement in a patient who had experienced a head injury.[46] Riley et al[47] suggested that failure to move from a sitting position to a standing position may be due to inadequate or poorly coordinated momentum generation in older adults. Schenkman and colleagues[48] reported that older adults increase their trunk flexion angular velocity to overcome mechanical difficulties with lower chair heights.

Slower sit-to-stand times have been related to greater deficits in instrumental activities of daily living[39] and to balance disorders in older adults.[35] In 1 prospective study of community-living older adults (N=1,500), 87% of the subjects could rise from a chair without using their upper extremities,[39] suggesting that function in instrumental activities of daily living is related to chair-rise time.

A commonly used self-administered questionnaire tool that helps to determine balance confidence in older people is the Activities-specific Balance Confidence Scale (ABC).[49] Scores on the ABC have been related to fall risk in older people.[50] Another tool that has been used to assess gait in older people with balance dysfunction is the Dynamic Gait Index (DGI) developed by Shumway-Cook and Woollacott.[51] Lower scores on the DGI have been related to higher risk for falling in older people.[52]

Because the FTSST is easy to administer and has been used widely, we believed that it was important to determine whether there were differences between people without balance disorders and people with balance disorders in order to validate the tool for use with people with balance dysfunction. The purpose of this study was to describe the ability of the FTSST to discriminate between subjects with balance and vestibular disorders and subjects without such disorders (control subjects). In addition, DGI and ABC scores were compared with FTSST scores in order to establish concurrent validity. The control group was included in this project in order to determine whether the FTSST is a measurement of transitional movement deficit that is caused by vestibular dysfunction. Older and younger people were included in order to determine whether there were age effects on FTSST performance and to determine whether there was a differential effect of disease between young and older people with and without balance and vestibular dysfunction. Sex also was tested to determine whether it was a potential confounder.

Method

Data for each control subject were collected with informed consent as part of 3 ongoing studies. Data for subjects with balance or vestibular disorders were collected as part of an evaluation of the subjects' physical performance during an initial physical therapy assessment and were obtained retrospectively.

Control Subjects

Control subjects were recruited via newspaper advertisement and flyers between June 1995 and August 2001 for 2 National Institutes of Health studies on healthy aging and for a postural control study. Subjects had to meet the following stringent criteria in order to be eligible to participate: (1) no history of otologic or neurologic disease; (2) normal vestibular function, as measured by the caloric test for vestibular function and earth vertical axis rotational testing; (3) no history of whiplash or other neck injury; (4) no history of lower-extremity or spine pathology that would influence the ability to stand; and (5) a Mini-Mental State Examination score greater than 24/30.[53] All subjects were screened by a board-certified neurologist to ensure that they did not have any comorbid neurologic disorders. Vision also was screened to ensure that it was at least 20/40 corrected, and hearing was tested to ensure that it was within normal limits for the ages of the subjects.

A total of 81 control subjects were included (39 men and 42 women). The subjects were divided into 2 age groups: those 60 years of age and older and those younger than 60 years. There were 49 older control subjects with a mean age of 73 years (SD=5, range=63–84; 23 men and 26 women) and 32 younger control subjects with a mean age of 41 years (SD=11, range=23–57; 16 men and 16 women). Descriptive data for the subjects are included in Table 1.

Table 1.
Age, Sex, Five-Times-Sit-to-Stand Test (FTSST) Scores, Dynamic Gait Index (DGI) Scores, and Activities-specific Balance Confidence Scale (ABC) Scores for Younger and Older Subjects With and Without Balance Dysfunction

Variable	Younger Control Subjects (n=32)	Younger Subjects With Balance Dysfunction (n=47)	Older Control Subjects (n=49)	Older Subjects With Balance Dysfunction (n=46)
Age (y)				
$\bar{X}$	41	48	73	75
SD	11	10	5	7
Range	23–57	14–59	63–84	61–90
Sex				
Men	16	15	23	18
Women	16	32	26	28
FTSST score (s)				
$\bar{X}$	8.2	15.3	13.4	16.4
SD	1.7	7.6	2.8	4.4
Range	4.9–12.7	6.4–56.6	7.5–19.6	9.6–27.5
95% CI[a]	7.5–8.8	13.1–17.6	12.5–14.1	15.1–17.7
DGI score				
$\bar{X}$	23.9	18.0	22.2	15.8
SD	0.3	4.4	1.7	5.1
Range	23–24	7–24	15–24	4–23
95% CI	23.9–24	16.7–19.4	21.5–22.5	14.3–17.3
ABC score				
$\bar{X}$	98.2	65.0	88.0	60.6
SD	4.2	21.7	19.1	22.1
Range	78–100	0–100	60.6–100	12–98
95% CI	96.7–99.7	58.3–71.6	79–95.2	53.9–68

[a] 95% CI=95% confidence interval.

Subjects With Balance or Vestibular Disorders

Data for subjects with balance or vestibular disorders were collected during a retrospective chart review of people who had received physical therapy for balance or vestibular disorders between January 2001 and November 2001. All subjects had a balance or vestibular disorder diagnosed by the referring physician and were seen in a tertiary care balance and vestibular clinic. Subject data were included if the subject had completed the FTSST during the initial physical therapy visit. A total of 93 subjects met the criteria and were included in the study. The data collected from the subjects' charts included age, sex, FTSST score, ABC score, DGI score, and vestibular test results, which were recorded as "normal" or "abnormal."

Diagnoses were derived from the physician examination and vestibular test results. A total of 72 subjects underwent caloric testing (42 normal [58%] and 30 abnormal [42%]); 68 underwent rotational chair testing (35 normal [52%] and 33 abnormal [48%]); 77 underwent oculomotor testing (71 normal [92%] and 6 abnormal [8%]); 74 underwent positional testing (61 normal [82%] and 13 abnormal [18%]); and 93 underwent computerized dynamic posturography testing, with 23 (25%) falling on both conditions 5 and 6. A fall on conditions 5 and 6 meant that the subjects either took a step or reached for the wall when they were standing on a sway-referenced support surface (as the subjects swayed forward and backward, the floor moved under their feet the same amount as their forward or backward sway) with their eyes closed and when their eyes were open with the walls sway referenced. The mean length of balance or dizziness symptoms in all of the subjects was 14.3 months (SD=13.8, range=4–30). The subjects were divided into 2 age groups: those 60 years of age and older and those younger than 60 years. The charts of 47 subjects who were younger than 60 years were reviewed. The mean age of those subjects was 48 years (SD=10, range=14–59; 15 men and 32 women). The mean age of the other 46 subjects (60 years and older) was 75 years (SD=7, range=61–90; 18 men and 28 women).

Procedure

Physical performance testing was scheduled on a different day than otologic testing for subjects with balance or vestibular disorders and for control subjects. The first author collected data for all of the older control subjects over the 6-year period. The other physical therapists who recorded subject data (n=2) were trained by the first author. Before the start of this study, both physical therapists demonstrated the ability to administer the FTSST to within ±1 second of the time of the first author for 4 nonstudy subjects with balance disorders. These 2 physical therapists were instructed to use the same verbal instructions as the first author during their training on how to perform the FTSST. The second author collected data for all of the younger control subjects and was 1 of the 2 trained physical therapists also collecting data for subjects with balance or vestibular disorders.

All participants were asked to perform 2 functional performance tasks as part of their physical performance testing: the FTSST and the DGI.[51] The ABC (self-report measure) was completed on the same day as the performance tasks.[49,54]

All subjects (subjects with balance or vestibular disorders and control subjects) began by crossing their arms on their chest[34] and sitting with their back against the chair (43-cm height, 47.5-cm depth). The examiner provided the following instructions according to the standardized laboratory protocol: "I want you to stand up and sit down 5 times as quickly as you can when I say 'Go'." Timing began when the examiner said "Go" and stopped when the subject's buttocks touched the chair on the fifth repetition. The investigator instructed the subject to stand up fully between repetitions of the test. Subjects were instructed not to touch the back of the chair during each repetition. Subjects were allowed to place their feet comfortably under them during testing. Occasionally, it was noted that subjects moved their feet during the testing, especially those who had difficulty with their balance during testing. Lord et al[4] used the same FTSST protocol and reported an intraclass correlation coefficient of .89 for reliability of the FTSST in 30 older community-living adults. Other investigators[55] also have reported stability of the FTSST over 3 separate days during a 1-week period.

The DGI assesses 8 different aspects of gait performance with a total score of 24.[51] Items include walking, walking at different speeds, walking with the head in the pitch (up/down) and yaw (right/left) planes, walking and turning, walking around and over obstacles, and stair climbing. Wrisley et al[56] reported a kappa value for interrater reliability of .64 and a Spearman rho value of .95 when the DGI was performed concurrently with 2 testers and a group of subjects with peripheral vestibular disorders. Shumway-Cook et al[52] reported an interrater reliability of $\geq$ .96 for the DGI for older community-living people. The authors reported a range of interrater reliability coefficients (type not specified), but all scores were $\geq$.96.

The ABC is a self-report measure of balance confidence with scores that vary between 0 and 100. People rate their perceived ability to perform 16 different activities ranging from walking around the house or reaching for an object at shoulder level to walking outside on an icy sidewalk. The ABC has been reported to yield valid scores in people with vestibular disorders.[57] Higher scores indicate greater confidence in performing 16 activities of daily living. Low scores (<50) have been related to being homebound in older adults.[58]

Data Analysis

Statistical analysis was performed by use of SPSS version 11.0* and Analyze-It Clinical Laboratory version 1.68.† Means, standard deviations, and 95% confidence intervals (CIs) for the FTSST were determined relative to both age group and disease status (without or with a balance disorder). Spearman rank-order correlations were used to determine the concurrent validity of data for the FTSST with the DGI and with the ABC.

A 2-way analysis of variance was used to determine the main effects of the presence of a balance disorder (subjects with balance or vestibular disorders versus control subjects) and age group (younger than 60 years of age versus 60 years of age and older) as well as a disease-age group interaction on FTSST performance. Sixty years of age was chosen as the cutoff point for older and younger age groups because it was close to the mean age of the subjects (60.7 years) and because there was a break in the frequency distribution for the variable of age at that value.

The discriminant validity, or the ability to discriminate between subjects with balance disorders and those without balance disorders, of data for the FTSST, DGI, and ABC was assessed by use of discriminant function analysis and receiver operating characteristic (ROC) curve analysis. Discriminant analysis is a technique used to describe the relationships between a nominal variable, such as group membership, and a set of quantitative independent variables. In this analysis, a discriminant function equation as a weighted combination of independent variables is used to classify subjects into a dependent-variable group. The difference between groups on the basis of the combined effect of the variables in the function equation is tested against the null hypothesis of no difference between groups. The classification predicted on the basis of the independent variables is compared with actual group membership for accuracy. The best subset of variables that can maximize the difference between groups and minimize misclassification errors then can be determined. Multivariate linear discriminant analysis was used to evaluate the ability of the FTSST, DGI, and ABC to predict group membership (control subjects versus subjects with balance or vestibular disorders).

The ROC curve analysis is a technique that allows the evaluation of the sensitivity and specificity for positive and negative results at various cutoff point levels of a dependent variable. Examination of these properties associated with an outcome of interest, such as disease presence or absence, allows identification of the value of an independent variable most likely to maximize discrimination for that outcome (cutoff point). A curve is generated as a graphic depiction of the relationship between sensitivity and false-positive rate (1 – specificity) across values of the independent or predictor variable. The area under the curve (AUC) is determined and tested against a null hypothesis of no discrimination (AUC=.50). From the curve, the value of the predictor variable that optimizes the discriminant properties for the outcome can be determined for use in future clinical

* SPSS Inc, 233 S Wacker Dr, Chicago, IL 60606.

† Analyse-It Software Ltd, PO Box 103, Leeds LS27 7WZ, United Kingdom.

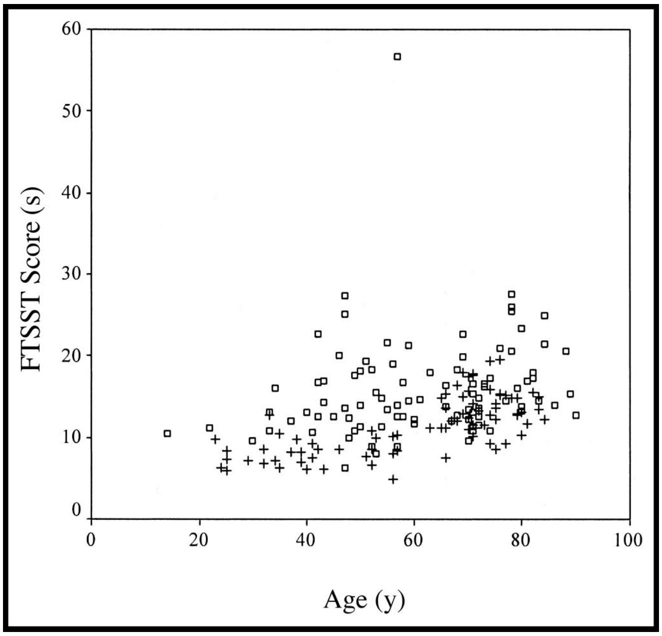

Figure 1.
Five-Times-Sit-to-Stand Test (FTSST) scores (in seconds) by age (in years) and category (subjects with balance or vestibular disorders [squares] and control subjects [crosses]) for all subjects.

screening or classification decisions. If the ROC AUC is significantly greater than .50, then the FTSST, ABC, and DGI have a greater ability to predict membership in the group of subjects with balance or vestibular disorders than to predict membership in the group of control subjects.

A chi-square analysis was performed to determine whether a combination of quantitative and qualitative balance measures would enhance the discriminative ability to predict group membership. The ability to discriminate group membership for subjects younger than 60 years of age and those older than 60 years of age also was calculated by use of a chi-square analysis. A *P* value of .05 was used to determine statistical significance for all analyses.

Another *post hoc* test was performed to determine the degree to which a subject's age or sex predicted performance on the Sit-to-Stand Test. Linear regression analysis with age or sex as a predictor of the FTSST score was performed for all subjects and separately for subjects with balance or vestibular disorders and control subjects.

Results

Figure 1 illustrates each subject's FTSST score by age group and disease status and indicates a potential outlier with an unusually long FTSST time in the group of subjects with balance or vestibular disorders. The mean, range, and 95% CIs for the FTSST scores of the 4 groups created by dichotomizing age at 60 years are shown in Table 1. Results of the 2-way analysis of variance demonstrated significant disease ($F=44.9$, $P<.01$) and age group ($F=19.0$, $P<.01$) effects on FTSST scores. The subjects with balance or vestibular disorders had a slower mean FTSST time than the control subjects. Older subjects had slower times than younger subjects.

A significant disease-age group interaction was found. There was no significant difference in FTSST scores on the basis of sex across both groups (subjects with balance disorders and subjects without balance disorders regardless of age).

Analysis of the 95% CIs for the effect of age (younger than 60 years versus older than 60 years) on balance dysfunction showed that the younger control group had significantly faster performance than the younger balance disorder group and both older groups (Tab. 1). The older control group had significantly faster FTSST times than the older balance disorder group. No significant difference was found between the older and the younger balance disorder groups or between the older control and the younger balance disorder groups. Elimination of the outlier in the younger balance disorder group (FTSST score=56.6 seconds) (Fig. 1) from the analysis had no effect on these results; therefore, the analysis included all subjects. There was no statistically significant difference in FTSST scores when the older control subjects were divided into various age categories (60–69 years, 70–79 years, and 80–89 years).

The concurrent validity of data for the FTSST was examined. The Spearman rho between the FTSST and the DGI was –.68 ($P<.001$), and that between the FTSST and the ABC was –.58 ($P<.001$). The mean ABC and DGI scores for the 4 groups are included in Table 1. The 95% CIs shown in Table 1 indicate that the ABC and DGI scores were significantly higher in both younger and older control subjects than in subjects with balance dysfunction.

An FTSST time of 13 seconds was judged to represent the best combination of sensitivity (66%) and specificity (67%) for the entire study sample. Optimal sensitivity and specificity decisions were based on the work of Rao[59] and Jaeschke et al.[60] At the cutoff value of 13 seconds, the positive predictive value of the FTSST for group membership was 61%, and the negative predictive value was 54%. The ability of the FTSST to identify subjects with balance dysfunction was improved in subjects younger than 60 years of age compared with those subjects older than 60 years of age. Optimal sensitivity (87%) and optimal sensitivity (84%) were achieved for subjects younger than 60 years of age at a cutoff point of 10 seconds. In contrast, optimal sensitivity (61%) and optimal specificity (59%) in subjects older than 60 years of age were obtained at 14.2 seconds.

Figure 2A shows the ROC curve for the ability of the FTSST to identify subjects with balance dysfunction versus control subjects. The AUC analysis indicated a significant curve area (AUC=.75, 95% CI=.68–.82, $P<.001$) compared with the null hypothesis of no discrimination (AUC=.50). Figure 2B shows the ROC curve for the ability of the FTSST to identify subjects with balance or vestibular disorders versus control subjects for people younger than 60 years of age. The AUC analysis revealed a significant and larger effect in younger subjects than in the entire study sample (AUC=.94, 95% CI=.88–.99, $P<.001$). Figure 2C shows the ROC curve for subjects older than 60 years of age. The AUC analysis also indicated a significant curve area (AUC=.68, 95% CI=.58–.79, $P<.001$) for older subjects.

Figure 3 shows ROC curves for the ABC and DGI for all subjects (Fig. 3A), subjects younger than 60 years of age (Fig. 3B), and subjects 60 years of age and older (Fig. 3C). For all subjects, optimal identification of people with balance dysfunction was obtained at an ABC cutoff point of 85 (sensitivity=83%, specificity=90%). The ability of the ABC to identify people with balance dysfunction was improved for subjects younger than 60 years of age when an ABC cutoff point of 96 was used (sensitivity=96%, specificity=94%). For subjects 60 years of age and older, optimal identification of people with balance dysfunction was obtained at an ABC cutoff point of 85 (sensitivity=85%, specificity=81%). All AUC analyses for the ABC ROC curves shown in Figures 3A–C were significant at $P<.001$.

For all subjects, optimal identification of people with balance dysfunction was obtained at a DGI cutoff point of 22 (sensitivity=82%, specificity=88%) (Fig. 3A). The ability to identify people with balance dysfunction was improved for subjects younger than 60 years of age when a DGI cutoff point of 23 was used (sensitivity=96%, specificity=94%) (Fig. 3B). For subjects 60 years of age and older, optimal identification of people with balance dysfunction was obtained at a DGI cutoff point of 21 (sensitivity=80%, specificity=81%) (Fig. 3C). All AUC analyses for the DGI ROC curves shown in Figures 3A–C were significant at $P<.001$.

The significance of the univariate and multivariate discriminant model functions for the FTSST, DGI, ABC, and all combinations was evaluated by use of a chi-square distribution with degrees of freedom equal to the number of variables in the model. The percentages of subjects with balance disorders and control subjects correctly identified by each discriminant model are shown in Table 2. For all subjects and those 60 years of age and older, the ABC appears to be the optimal tool for discriminating between people with and people without balance disorders. The ABC and DGI better

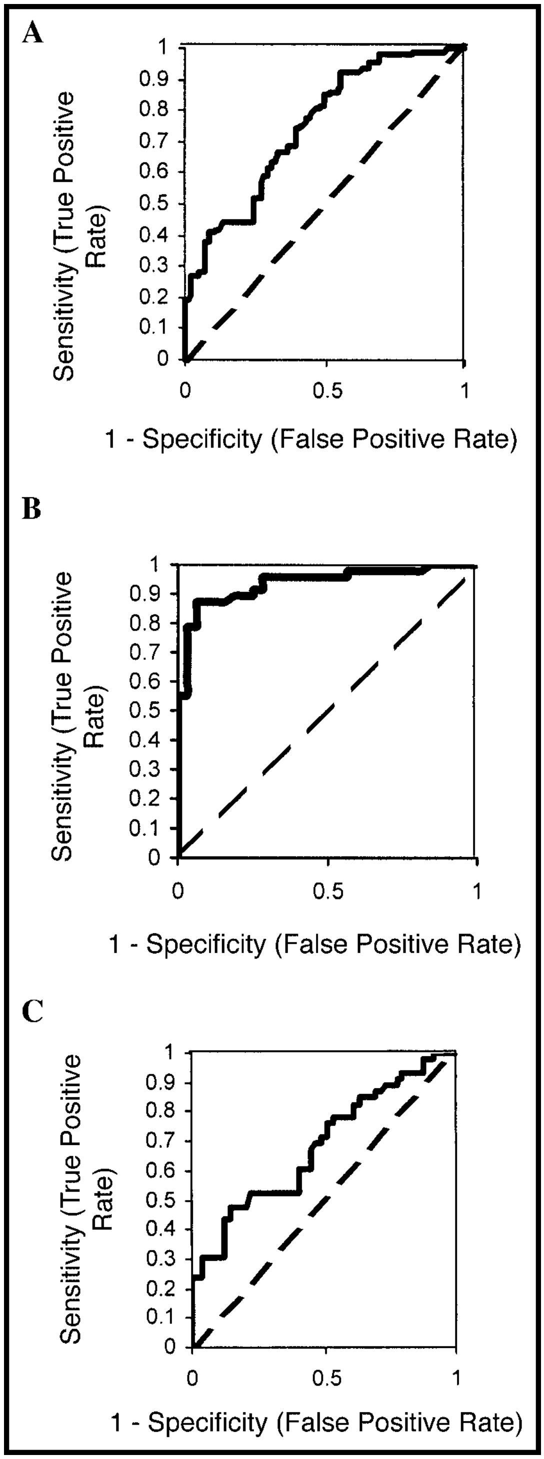

Figure 2.
Receiver operating characteristic curves for the Five-Times-Sit-to-Stand Test (FTSST) for detecting subjects with balance or vestibular disorders versus control subjects: (A) all subjects, (B) subjects younger than 60 years of age, and (C) subjects 60 years of age and older. The dashed line indicates level of no value in discriminating vestibular dysfunction.

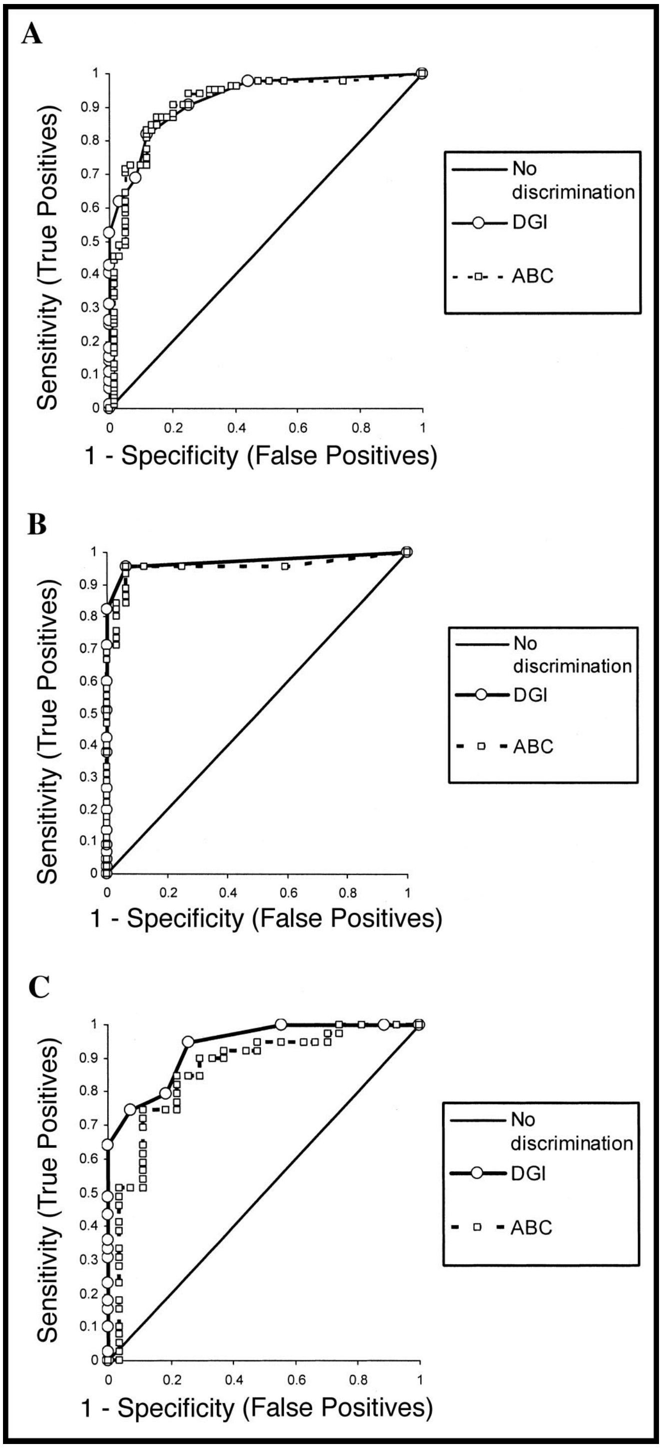

Figure 3.
Receiver operating characteristic curves for the Dynamic Gait Index (DGI) and the Activities-specific Balance Confidence Scale (ABC) for discrimination of subjects with balance dysfunction from control subjects: (A) all subjects, (B) subjects younger than 60 years of age, and (C) subjects 60 years of age and older.

Table 2.
Percentages of Control Subjects and Subjects With Balance Disorders Correctly Identified by Univariate and Multivariate Discriminant Models[a]

Discriminant Model	% of Subjects Correctly Identified by Model: All	Younger Than 60 y	60 y of Age and Older
FTSST	65	81	60
ABC	81	87	79
DGI	78	82	83
FTSST and ABC	83	89	76
FTSST and DGI	78	80	86
ABC and DGI	85	88	79
FTSST, ABC, and DGI	85	88	80

[a] All discriminant model functions were found to be significant when analyzed by the chi-square distribution at $P<.001$. FTSST=Five-Times-Sit-to-Stand Test, ABC=Activities-specific Balance Confidence Scale, DGI=Dynamic Gait Index.

discriminated between people with balance disorders and people without balance disorders than the FTSST. Adding the FTSST to either the ABC or the DGI or both did not noticeably improve the ability to discriminate between people with and people without balance disorders.

The *post hoc* linear regression analysis of the effect of age on FTSST showed that age was a stronger predictor of FTSST scores in control subjects than in subjects with balance dysfunction. For all subjects (those without and those with balance disorders), age predicted 11% of the variance ($P<.001$) in FTSST scores. When control subjects and subjects with balance disorders were analyzed separately, age predicted 48% ($P<.001$) and 11% ($P<.06$), respectively, of the variance in FTSST scores.

Discussion

The FTSST is able to assist in discriminating whether a subject has a balance disorder or is a control subject, but the ABC and the DGI have better discriminative properties. In choosing a tool to assist in discriminating subjects with balance disorders from control subjects, regardless of age, these findings suggest that the ABC would be the test with the strongest discriminative properties. For subjects younger than 60 years of age, the ABC continues to be the optimal tool, and for subjects 60 years of age and older, the DGI may be the optimal tool (Tab. 2).

The ABC was the best tool for discriminating whether a subject had a balance disorder. It is also the easiest tool to administer in a group setting. For screening purposes, asking a person to complete a 16-item questionnaire takes much less time than administering either the FTSST or the DGI. Health care workers could monitor the balance confidence of older adults with repeated testing in order to identify early balance decline.

The ABC takes 5 minutes for people to complete. Scores on the ABC have been related to scores on the Berg Balance Scale,[50] reported falls in older people,[50] hip flexor torque,[61] and physical activity plus perceived health in older people.[61] Scores on the ABC were related to scores on the Dizziness Handicap Inventory[62] (a questionnaire that attempts to quantify perceived handicapping effects of dizziness) in a group of patients of all ages with balance and vestibular disorders.[57] Hatch et al[63] reported a Pearson correlation of .72 between ABC and Berg Balance Scale scores in community-dwelling older people. The results obtained by Parry et al[64] support our findings. Their British version of the ABC was better than the British version of the Falls Efficacy Scale[65] at distinguishing between younger and older subjects and at distinguishing between people who reported falls and those who did not report falls. In our study, the ABC discriminated better than the DGI and the FTSTS between people with and people without balance disorders.

Although the ABC is better at discriminating between people with and people without balance disorders, the FTSST still may be helpful in quantifying a transitional movement that is performed daily. The FTSST appears to be more useful with younger subjects, because their scores were markedly different in subjects with balance disorders and control subjects (Tab. 1). Age predicted 48% of the variance in FTSST scores in control subjects versus only 11% of the variance in FTSST scores in subjects with balance disorders; these data suggest that other factors, such as dizziness, weakness, or impaired motor strategies, may influence the scores on the FTSST in subjects with balance disorders.

The FTSST scores of younger people with balance dysfunction in our study indicated that they had significant impairment. Seeman et al[40] reported a score of 12.3 seconds for the FTSST in people who were 70 to 79 years of age, whereas younger people with balance disorders in our sample had a mean FTSST score of 15.3 seconds. Guralnik et al[42] reported mean scores of 15 to 16 seconds in men and women older than 80 years. Lord et al[4] reported a weak correlation between advanced age and FTSST scores. Their reported FTSST scores were 12.1 seconds for men and 12.2 seconds for women in the age range of 70 to 79 years, similar to our reported data. The weak association with age appears to have occurred in a fashion similar to that found by Lord et al,[4] who showed an increase in FTSST scores only in people older than 85 years, thus establishing the age relationship. Had there been many older subjects older than 85 years in our sample, the same finding might have occurred.

It is interesting that there was no difference between younger and older adults with balance dysfunction. People with dizziness often move slowly to avoid provoking their dizziness symptoms.[66] There may be a threshold at which, if a person with balance or dizziness dysfunction moves faster, then their symptoms increase. This scenario could explain why the younger people with balance dysfunction were 8 seconds slower in accomplishing the same FTSST task than their younger peers without balance dysfunction.

No significant change in FTSST scores with advancing age was found in our older control subjects across decades; this was an unexpected result. All of the subjects were reasonably healthy and living independently in the community, and the FTSST may not have taxed them enough to demonstrate changes over these decades. Schultz et al[45] reported that rising from a chair requires only moderate torque in older adults relative to the maximum torque that older adults who are healthy can generate. It may have been too easy a test for these older adults.

Additional repetitions would have made the task more difficult and might have spread out the distribution. Five repetitions of moving from sitting to standing from a standard-height chair may be too easy a task to differentiate healthy people older than 60 years and younger than 80 years from people with balance or vestibular dysfunction. However, in our opinion, 5 repetitions represent a clinically reasonable approach.

One of the limitations of this study was that the height of the subjects was recorded only for the control group. A *post hoc* analysis determined that there was no difference on the basis of height of the control subjects. Height was shown to predict 2% of the variance in FTSST performance in the control subjects. Other authors[4] have reported no differences in rise times in older adults who are healthy on the basis of height.

Another limitation was that the height of the chair was not adjusted to the subject's height. Standing from a lower-height chair might have distributed the scores further, resulting in greater discriminative ability. Mazza et al[67] recently reported that adjustments in seat height changed older adults' sit-to-stand strategies. The lower floor-to-seat distance affected people who were more impaired as well as those who were shorter in stature. Mazza et al[67] suggested that the FTSST be performed from an adjustable-height chair. Hughes et al[68] reported changes in the biomechanical strategies used on the basis of chair height. Hughes and Schenkman[13] suggested that the strategies used to rise from a chair are different in adults who are functional impaired compared with adults who are healthy. Other authors[48,69,70] also have reported that chair height affects sit-to-stand performance. Future investigations should consider an adjustable-height chair, as the height of a chair can affect whether an older adult is able to rise from the chair, although functionally it is important to determine whether someone can rise from a typical-height chair found in the community.

The FTSST, ABC, and DGI tools obviously measure similar, yet slightly different, concepts. There was an enhanced predictive ability to discern subjects with balance dysfunction from subjects without balance dysfunction on the basis of a combination of the results from the FTSST, ABC, and DGI or a combination of the results from the ABC and DGI (both at 85% discriminative ability) (Tab. 2). The positive predictive value of the FTSST for identification of vestibular dysfunction was moderately high (61%). The use of the FTSST, ABC, and DGI tools might aid clinicians in judging whether an individual fits the profile of someone with a balance disorder.

The optimal sensitivity and specificity scores for the FTSST were 10 seconds for the younger subjects and 14.2 seconds for the older subjects. These FTSST times could be used by clinicians to set goals for an individual's rehabilitation program.

Conclusion

The FTSST is capable of identifying people with balance disorders. Its discriminative properties are enhanced when used with people younger than 60 years of age. The FTSST scores correlate well with scores on both the ABC and the DGI. The ABC has the best ability to discriminate between people with and people without balance disorders; adding the FTSST to the ABC or the DGI, or both, does not improve the ability to discriminate between people with and people without balance disorders. Because the FTSST measures the ability to perform a functional transitional movement, consideration should be given to performing the FTSST when examining people with suspected balance disorders. There was a moderate correlation between the FTSST scores and the scores for ABC plus the DGI.

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