Functional Gait Assessment: Concurrent, Discriminative, and Predictive Validity in Community-Dwelling Older Adults

Diane M. Wrisley, Neeraj A. Kumar

Background. The Functional Gait Assessment (FGA) is a reliable and valid measure of gait-related activities.

Objective. The purpose of this study was to determine the concurrent, discriminative, and predictive validity of the FGA in community-dwelling older adults.

Design. This was a prospective cohort study.

Methods. Thirty-five older adults aged 60 to 90 years completed the Activities-specific Balance Confidence Scale (ABC), Berg Balance Scale (BBS), Dynamic Gait Index (DGI), Timed "Up & Go" Test (TUG), and Functional Gait Assessment (FGA) during one session. Falls were tracked by having participants complete a monthly fall calendar for 6 months. Spearman correlation coefficients were used to determine concurrent validity among the ABC, BBS, TUG, DGI, and FGA. To determine the optimum scores to classify fall risk, sensitivity (Sn), specificity (Sp), and positive and negative likelihood ratios (LR+ and LR−) were calculated for the FGA in classifying fall risk based on the published criterion scores of the DGI and TUG and for the FGA, TUG, and DGI in identifying prospective falls. Receiver operator curves with area under the curve were used to determine the effectiveness of the FGA in classifying fall risk and of the DGI, TUG, and FGA in identifying prospective falls.

Results. The FGA correlated with the ABC (r=.053, P<.001), BBS (r=.84, P<.001), and TUG (r=−.84, P<.001). An FGA score of ≤22/30 provides both discriminative and predictive validity. The FGA (scores ≤22/30) provided 100% Sn, 72% Sp, LR+ of 3.6, and LR− of 0 to predict prospective falls.

Limitations. The study was limited by the length of time of follow-up and the small sample size that did not allow for evaluation of criterion scores by decade.

Conclusions. The FGA with a cutoff score of 22/30 is effective in classifying fall risk in older adults and predicting unexplained falls in community-dwelling older adults.

D.M. Wrisley, PT, PhD, NCS, is Assistant Professor, Department of Rehabilitation Science, State University of New York, University at Buffalo, 515 Kimball Tower, 3435 Main St, Buffalo, NY 14214 (USA). Address all correspondence to Dr Wrisley at: dwrisley@buffalo.edu.

N.A. Kumar, PT, PhD, is Assistant Professor, Department of Rehabilitation Science, Texas Tech University Health Sciences Center, Odessa, Texas.

[Wrisley DM, Kumar NA. Functional gait assessment: concurrent, discriminative, and predictive validity in community-dwelling older adults. *Phys Ther.* 2010;90:761–773.]

Falling in older adults is among the top public health issues in the United States. Approximately 35% of adults over the age of 65 years fall each year, and the risk of falling increases to 50% in adults over the age of 70 years.[1–3] Falls in elderly people have been associated with significant decline in function and increased mortality and morbidity.[4–7] Many factors may contribute to falling in elderly people, including lower-extremity weakness, balance disorders, functional and cognitive impairments, visual deficits, polypharmacy, and environmental factors.[8] Postural instability and gait abnormalities are strongly associated with falling in elderly people. Frequently, older adults are not aware of their risks of falling and do not report these issues to the health care professionals who care for them.[8] Consequently, opportunities for prevention of falls often are overlooked, with the risk of falling evident only after injury and disability have occurred.[9–11] Recognition of older adults at risk for falls is an important task for physical therapists, as there is increasing evidence that frequency and consequences of falls can be decreased through interventions.[12–15]

The development and use of tools that screen for fall risk are useful to identify those older adults who require evaluation as to the cause of falling in order to prescribe the appropriate intervention. Several fall risk screening tools have been developed for and tested with older adults.[16–20] These tools include the Timed "Up & Go" Test (TUG),[18] the Berg Balance Scale (BBS),[16,21] the Performance-Oriented Mobility Assessment (POMA),[20] and the Dynamic Gait Index (DGI).[19] The specificity (SP) and sensitivity (Sn) of these tools to identify individuals at risk for falls range from 59% to 89%,[7,17,22–26] yet the majority of these tools were validated by their ability to discriminate between those with a history of falling and those who had not fallen.[17,20,22,24] The gold standard is to validate the tools prospectively to determine whether the clinical performance tool can determine who will fall within a specified period of time. Many of these clinical performance tests, such as the POMA,[20] BBS,[25] and DGI,[27] appear to have a ceiling effect in community-living older adults and are not sensitive to minor differences among individuals that may indicate risk for falls and may direct intervention.

The Functional Gait Assessment (FGA)[28] is a modification of the DGI[19] that was developed to improve the reliability of the DGI and to reduce the ceiling effect seen with the DGI in patients with vestibular disorders.[27] The FGA is a 10-item clinical gait test during which participants are asked to perform the following gait activities: walk at normal speeds, at fast and slow speeds, with vertical and horizontal head turns, with eyes closed, over obstacles, in tandem, backward, and while ascending and descending stairs.[28] The FGA is scored on a 4-level (0–3) ordinal scale; scores range from 0 to 30, with lower scores indicating greater impairment. In adults with vestibular disorders, the interrater reliability of the FGA was reported as r=.86 (intraclass correlation coefficient [ICC (2,1)]) and intrarater reliability as r=.74 (ICC [2,1]).[28] Individual FGA item interrater and intrarater reliability ranged from r=.16 to r=.83 (kappa). Walker et al[29] found the interrater reliability of the FGA to be r=.93 (ICC [2,1]) in community-dwelling adults following a training session of the raters. In people with vestibular and balance disorders, the FGA correlated with the Activities-specific Balance Confidence Scale (ABC) (r=.64), the Dizziness Handicap Inventory (r=−.64), perceived symptoms of dizziness (r=−.70), number of falls in the previous 6 months (r=−.66), the TUG (r= −.50), and the DGI (r=.80).[28] The FGA eliminated the ceiling effect in the DGI seen when testing people with vestibular dysfunction.[28] Walker et al[29] provided reference group data for the FGA in community-dwelling adults in decades from age 20 to 90 years. They found that total FGA scores decreased by decade over the age of 60 years, with adults over the age of 80 having significantly lower scores. For adults up to the age of 60 years, the normal score on the FGA would be considered >27/30; for adults from ages 60 to 80 years, the normal score on the FGA would be considered >24/30; and for adults over the age of 80 years, the normal score would be considered >19/30.[29] However, no protocol was included that would ensure that the participants' balance abilities were normal, and there was no significant history of falls. This is especially important when considering the normative scores for older adults above 80 years.

Due to the range of clinical gait activities within the FGA, we believe that it may be a more useful assessment tool to guide intervention to decrease fall risk in community-living older adults than currently used clinical measures such as the POMA, TUG, BBS, and DGI. However, the clinical usefulness of a test increases when clinicians know its concurrent, discriminative, and predictive validity. Discriminative and predictive validity may provide indications of which scores are within normal limits and which correctly

Table 1.
Participant Demographic Information[a]

Variable	All Participants	Nonfallers	Fallers	Significance (*P* Value)	Correlation With FGA
Age (y)	72.9 (7.8)	71.5 (7.2)	77.7 (7.8)	.14[b]	−.47 P=.005
Sex	18 F, 17 M	14 F, 15 M	4 F, 2 M	.95[c]	−.09 P=.603
Height (cm)	166.1 (10.7)	166.9 (10.7)	165.6 (11.9)	.90[b]	−.02 P=.93
Weight (kg)	75.3 (15.6)	73.5 (14.2)	86.4 (19.6)	.16[b]	−.08 P=.66
MMSE	28.7 (1.5)	28.9 (1.2)	28.7 (2.0)	.89[b]	.26 P=.13
ABC, range	90.5 (9.3), 64.4–100.0	91.2 (9.1), 64.4–100.0	86.5 (11.6), 66.3–95.0	.31[c]	.53 P<.001
Berg Balance Scale, range	52.7 (4.0), 38–56	53.8 (2.9), 46–56	47.8 (5.3), 38–54	.003[c]	.84 P<.000
Timed "Up & Go" Test, range	10.9 (4.1), 7.2–32.2	9.8 (1.6), 7.2–13.0	15.8 (8.2), 9.5–32.2	.001[b]	−.84 P<.000
Dynamic Gait Index, range	20.8 (3.4), 8–24	21.9 (2.3), 15–24	16.5 (4.6), 8–20	.001[c]	.94 P<.000
Functional Gait Assessment, range	23.3 (5.3), 9–30	24.9 (4.2), 15–30	16.2 (4.4), 9–20	.000[c]	

[a] Reported values are mean (SD), unless otherwise indicated. Nonfallers=participants who did not experience an unexplained fall in the 6 months following testing. Fallers=participants who experienced 1 or more unexplained falls in the 6 months following testing. An *explained fall* was defined as a fall that was unavoidable due to medical, environmental, or task-related causes. *Unexplained falls* are all other falls. M=male, F=female, MMSE=Mini-Mental State Examination, ABC=Activities-specific Balance Confidence Scale. Correlations with Functional Gait Assessment performed using Spearman correlation coefficient.
[b] Difference between fallers and nonfallers calculated using independent *t* test.
[c] Difference between fallers and nonfallers calculated using Mann-Whitney *U* test.

classify fall risk. The determination of a cutoff score for the FGA that classifies individuals who are at increased risk of falls would provide clinicians with an additional screening tool. Discriminative validity is determined by evaluating how well a tool differentiates between 2 groups. For assessment tools that screen for fall risk, the older adults are frequently divided into groups based on history of falls. As the participants of this study did not have a history of falls, they were classified as having an increased risk of falls using the previously published criteria of the TUG and DGI. The discriminative validity of the FGA was determined by how well it identified those older adults classified as having increased fall risk. The optimum cutoff score was selected based on the FGA score with the highest sensitivity and lowest negative likelihood ratio, as it would identify the fewest false negatives. The predictive validity of the FGA was determined by how well the proposed cutoff score, established during the evaluation of discriminative validity, identified older adults who fell in the following 6 months. Therefore, the purpose of this study was to determine: (1) the concurrent validity of the FGA with the ABC, BBS, and TUG, and (2) the discriminative and predictive validity of the FGA in classifying fall risk in older adults.

Method

Participants

Thirty-eight older adults were recruited as part of a larger study on the effect of age and functional level on balance. Demographic data are listed in Table 1. All participants met the following inclusion criteria: aged between 60 and 90 years; lived independently in the community; were able to stand independently longer than 1 minute; and had a Mini-Mental State Examination score of greater than 24. Participants were excluded if they had a history of osteoporosis, recent fractures, or lower-extremity surgery; had a history of progressive neuromuscular disorder; had a history of whiplash, neck injury, or current complaints of neck pain; had a history of unstable angina or uncontrolled cardiorespiratory problems; were taking any medications (eg, benzodiazepines, antidepressants, hypnotics) that might affect balance; had a history of any falls in the previous 6 months and more than one fall in the last year; had pain in any segment greater than 2/10 on a 10-point verbal analog scale (0="no pain," 10="worst pain imaginable"); or did not return the monthly fall calendar. Three participants were excluded because they did not return their monthly fall calendars.

We estimated that 30 participants were needed for a power of 92% using a conservative estimate of 65% positive predictive value and 90% negative predictive value for the chi-square analysis. The actual power of the chi-square analysis with the 35 participants included was 92% for the FGA versus prospective falls, 99% for the FGA versus the TUG (using >11.1 seconds as the cutoff), and 91% for the FGA versus the DGI. The inclusion of human participants in this study was approved by the Health Science Institutional Review Board of the University at Buffalo. All participants provided informed consent prior to the beginning of the study.

Procedure

During the same session, participants completed the following assessment in the order listed: TUG, BBS, DGI, and FGA. All tests were administered by the same rater (N.A.K.), a physical therapist with 8 years of experience, who was trained in the administration of the tests by the other author (D.M.W.), a physical therapist with extensive experience using the tests in the evaluation and treatment of patients with balance dysfunction and one of the developers of the FGA. The test items on the BBS, DGI, and FGA were administered in their published order.[16,18,19,28]

Participants completed the ABC[30,31] to quantify their confidence in the ability to maintain balance. The ABC was completed during breaks between the other tests. The ABC is a 16-item self-efficacy scale that is scored on a 10-point ordinal scale.[30,31] Participants rate their confidence in maintaining their balance while performing 16 activities of daily living (ADL). Test-retest reliability of the ABC completed by 60 community-dwelling older adults over a 2-week period was reported as r=.92 using the Spearman correlation coefficient.[31] Scores on the ABC range from 0, indicating no confidence in the patient's ability to maintain balance while completing the activity, to 100, indicating complete confidence. The ABC correlates with physical function level in older adults: scores of <50 indicate a low level of functioning seen with adults receiving home care, scores between 50 and 80 indicate a moderate level of functioning seen in older adults with chronic health problems or living in retirement centers, and scores greater than 80 indicate high functioning seen in physically active older adults.[32] Activities-specific Balance Confidence Scale scores of ≤67 indicate increased risk of falls.[33]

Participants completed the BBS as a means to quantify balance function. Although the BBS has a ceiling effect in community-dwelling older adults, it was included to provide a description of the participant sample and to illustrate the difference between those who prospectively experienced an unexplained fall and those who did not. The BBS is a 14-item clinical balance test that quantifies a person's ability to perform various sitting and standing activities such as standing from a chair, standing with feet together, reaching forward, and standing on one foot.[16,17] The test is scored on a 4-level ordinal scale, with lower scores indicating greater impairment. The test has interrater reliability of r=.98 (ICC)[16] and r=.88 (Spearman rho)[25] and correlates with the POMA (Pearson r=.91)[21] and the TUG (Pearson r=.76). Scores of less than 46/56 have been interpreted to indicate increased risk for falls in community-dwelling older adults, with a sensitivity (Sn) range of 64% to 82.5%, a specificity range of 90% to 94%, a positive likelihood ratio (LR+) of 6.1, and a negative likelihood ratio (LR−) of 0.4.[25,26,33] Scores of <50/56 have an LR+ of 3.1 and an LR− of 0.2 in community-dwelling older adults.[26]

The DGI[19] is a clinical gait test that was developed to assess fall risk in community-dwelling older adults. It is an 8-item test, rated on a 4-level ordinal scale, with lower scores indicating greater impairments. The DGI includes the activities of walking at normal speeds, walking at fast and slow speeds, walking with horizontal and vertical head turns, walking over and around obstacles, and ascending and descending stairs. The reliability of the DGI was .96 (using a ratio of subject variability to total variability) in community-dwelling older adults when the raters were trained by the developer of the test.[24] Interrater reliability was *kappa*=.64 when the test was used in patients with vestibular disorders[27] and r=.98 (ICC) in people with multiple sclerosis when videotaped.[34] The DGI correlates with the BBS (r=.67), the use of an assistive device (r=−.44), a history of imbalance (r=−.46), and the Balance Self-Perceptions Test (r=.76).[24] The DGI discriminates between older adults and individuals with vestibular disorders with and without a history of falling, with scores of 19 or less indicating an increased risk of falls.[35] The ability of the DGI to classify older adults at risk for falls with scores of ≤19/24 has been reported with an Sn of 59% and an Sp of 64%.[24] Due to the similarity of the tests, the DGI and FGA were performed concurrently. Items on the DGI and FGA that are similar were performed once and scored according to their published criteria. The DGI and FGA were performed in the published order of the tests. Participants were provided with the standard instructions for each item and with a demonstration of the item, if needed. A maximum of 2 opportunities were provided to complete each task. A participant received a score of 0 if he or she was unable to perform a task as per the instructions of the DGI and FGA.

The TUG is a modification of the Get Up and Go test.[18] For the TUG, participants are timed as they stand up from a chair with arms, walk 3 m (9.84 ft) at their self-selected gait speed, turn around, come back to the chair, and sit down. For this study, participants were allowed 1 trial for practice and then performed 3 trials. The average of the 3 trials was used for analysis. The TUG has test-retest reliability of r=.99 (ICC [2,1])[18] and correlates with gait speed (r=−.81), with the BBS (r=−.81), and with ADL function (Barthel Index, r=.78).[18] Validity indexes for the TUG appear to be population dependent. Scores ranging from 10 to 30 seconds have been suggested to classify fall risk in community-dwelling older adults.[18,22,36,37] Podsiadlo and Richardson[18] suggested that scores of <11 seconds indicated a low risk for falls, whereas scores of >19 seconds indicated a moderate to high risk for falls.[38] Shumway-Cook et al[22] found that scores on the TUG of >13.5 seconds classified fall risk with an Sn and Sp of 87% in community-dwelling older adults,[22] whereas Rose and Jones[36] found that scores of >10 seconds classified older adults with a history of falling with an Sn of 71% and an Sp of 89%. If a score of >13.5 seconds had been used by Rose and Jones,[36] only 30% of those with a history of falling would have been identified.

Trueblood et al[37] found that scores of >20 seconds resulted in an Sn of 10% and an Sp of 95% in classifying community-dwelling older adults who fell in the ensuing 6 months. They suggested that a TUG score of >10 to 12 seconds would be a more appropriate cutoff score to classify older adults who are at risk for falling. Scores of >11.1 seconds on the TUG were found to be more sensitive (80%) and specific (56%) in classifying adults with vestibular and balance dysfunction who had fallen (mean age=60 years).[23] Scores of >7.95 seconds were found to have an Sn of 30% and an Sp of 93% in classifying people with Parkinson disease (mean age [SD] for "fallers" [people with a history of falling]=73 [8.6] years; mean age [SD] for "nonfallers" [people without a history of falling]=66 [9.9] years),[39] and scores of >15.0 seconds resulted in an Sn of 96% and an Sp of 36% in classifying falls in older adults in a residential care facility.[40]

The cutoff score of ≥11.0 seconds, as suggested by Podsiadlo and Richardson[18] and Trueblood et al,[37] was used to determine discriminative and predictive validity. As our participants closely resemble the participants included by Trueblood et al[37] and were classified as fallers versus nonfallers by prospective falls, a cutoff score within the suggested range was appropriate.

To test the predictive validity of the FGA in identifying older adults who fell in the ensuing 6 months, all participants were provided with 6 months' worth of postage-paid fall calendar postcards and were asked to return them monthly.[41] Participants completed the calendar on a daily basis. If a fall occurred, a separate postcard was completed, providing details of the fall. The postcards were mailed back monthly, and if not received by the 10th of the following month, participants were contacted to remind them to return the cards. If participants returned a postcard indicating they had fallen, they were contacted via telephone or e-mail for additional details. *Falls* were defined as unintentionally coming in contact with any surface lower than the participant's height. Falls were further classified as *explained* or *unexplained*. A fall was considered explained if there was a medical, environmental, or task-related explanation for the fall that was unavoidable (eg, falling while skiing, slipping on ice, falling on stairs while moving furniture, a reaction to medication).[42] An unexplained fall was all other falls. Falls were classified by an investigator (D.M.W.) who was blinded to the participant's clinical test performance prior to the clinical test data being added to the falls database.

Data Analysis

The Spearman correlation coefficient was calculated between the TUG, ABC, and BBS to determine concurrent validity of the FGA. The discriminative validity of the FGA in classifying older adults who were at increased risk for falls by the TUG (scores ≥11.0 seconds)[18,37] and DGI (scores ≤19)[24] was determined using receiver operator curves (ROCs) with the area under the curve (AUC). The AUC was used to evaluate the effectiveness of the FGA in classifying fall risk. The greater the AUC, the better the test is in classifying fall risk. An area of 1 indicates 100% ability to classify fall risk, and an area of 0.5 indicates a 50% chance of correctly classifying fall risk. The determination of the optimum cutoff score for the FGA in correctly classifying fall risk in older adults was determined by calculating the Sn, Sp, LR+, and LR−. The scores with the highest Sn and lowest LR− were identified as the optimum cutoff scores for the FGA. The predictive validity of the FGA, TUG, and DGI in identifying future falls was determined using ROCs with the AUC. The AUCs of the tests were compared to determine which test was best in identifying future falls. The determination of the optimum cutoff score for the FGA, TUG, and DGI in correctly identifying future falls in older adults was determined by calculating the Sn, Sp, LR+, and LR−. The scores with the highest Sn and lowest LR−, therefore yielding the fewest number of false negatives, were determined to be the optimum cutoff scores for the FGA, TUG, and DGI. All statistics were performed using SPSS software, version 15.*

Role of the Funding Sources

This work was supported by New York Physical Therapy Association Research Designated Funds and University at Buffalo's Mark Diamond Research Fund.

Results

Thirty-five participants (92%) returned their fall calendars and were included in the study. The 3 participants who did not return their fall calendars and were not included in

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

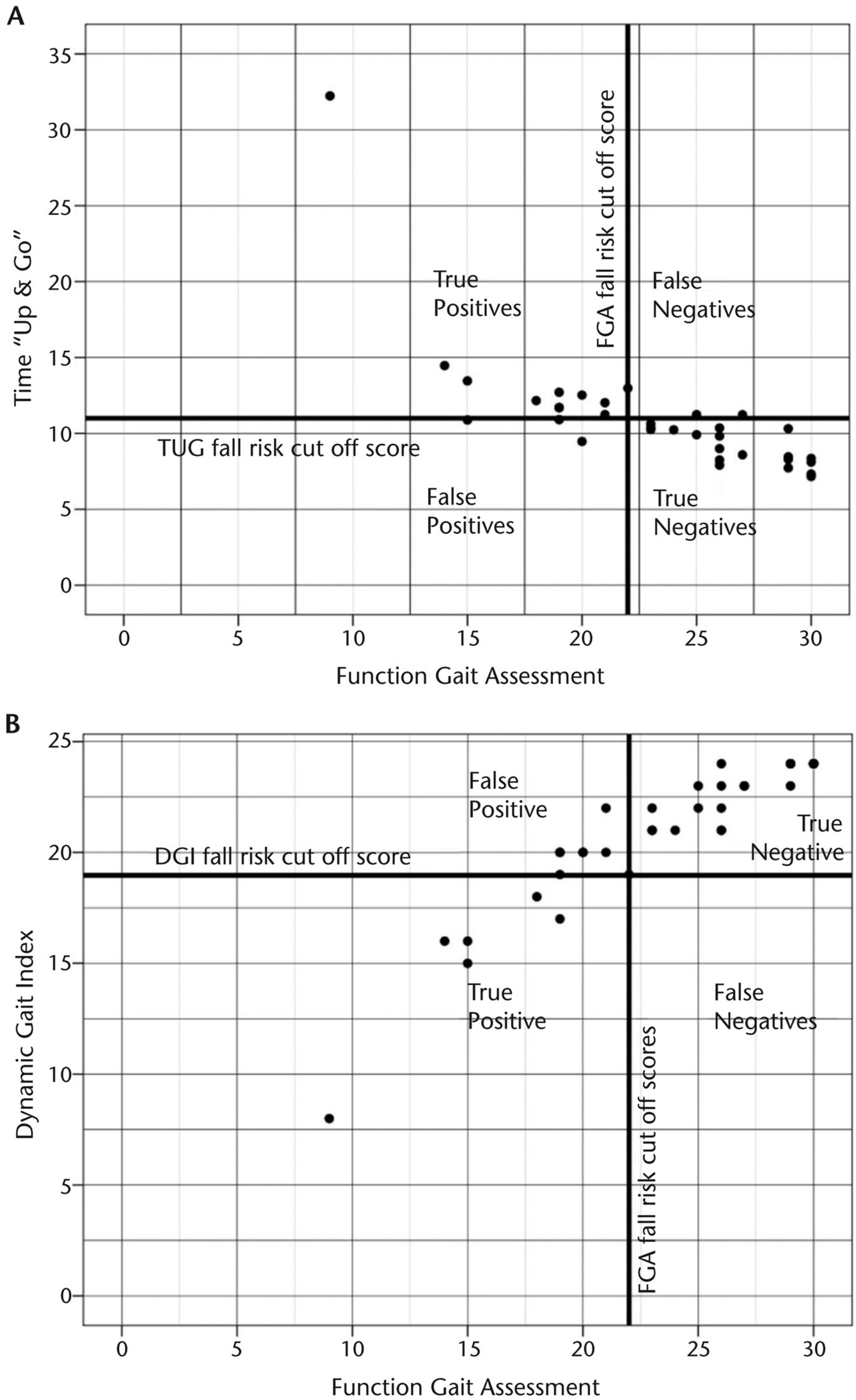

Figure 1.
Discriminative validity of the Functional Gait Assessment (FGA). (A) Relationship between FGA scores and Timed "Up & Go" Test (TUG) scores in community-dwelling older adults. The horizontal thick line is the published cutoff score for the TUG of ≥11 s.[18,37] The vertical thick line is the proposed cutoff score for the FGA of ≤22/30. (B) Relationship between the FGA scores and Dynamic Gait Index (DGI) scores in community-dwelling older adults. The horizontal thick line is the published cutoff score for the DGI of ≤19/24.[24] The vertical thick line is the proposed cutoff score for the FGA of ≤22/30. Note that there are overlapping data points, so the number of visible points on the graph may not equal the number of participants in each group.

the study did not respond to the telephone or e-mail reminders. There was no difference in demographics between those who returned their fall calendars and those who did not. Participant demographics are listed in Table 1.

Concurrent Validity

The FGA significantly correlated with the BBS, TUG, and ABC. Correlation coefficients and significance levels are listed in Table 1.

Discriminative Validity

Thirteen older adults were classified as at risk for falls based on the TUG (scores ≥11.0 seconds). The discriminative validity of the FGA is shown in Figure 1. The ROC for the FGA using the TUG scores for classification of fall risk is displayed in Figure 2A. The AUC was 0.87, indicating that the FGA correctly classified fall risk based on the TUG 87% of the time. The metrics for various values of the FGA to classify fall risk as indicated by TUG score are displayed in Table 2A. The optimum validity indexes are obtained with an FGA criterion score of ≤22, which results in an Sn of 91%, an Sp of 85%, an LR+ of 5.96, and an LR− of 0.09. Individuals who score ≤22/30 on the FGA are 6 times more likely to be classified as having an increased risk of falling (based on the TUG) than those who score >22/30. The metrics of the proposed cutoff score for the FGA (≤22/30) to classify risk for falls as determined by scores on the TUG are presented in Table 3A.

Eight older adults were classified as being at risk for falls based on the DGI (scores ≤19/24 indicate increased risk of falls). The ROC for the FGA using the fall risk classification of the DGI is displayed in Figure 2A. The AUC was 0.93, indicating that the FGA correctly classified fall risk based on the DGI 93% of the time. The metrics for various values of the FGA to classify fall risk as indicated by the DGI are displayed in Table 2B. As with the TUG, the optimum validity indexes are obtained with an FGA criterion score of ≤22, resulting in an Sn of 100%, an Sp of 78%, an LR+ of 4.5, and an LR− of 0. Individuals who score ≤22/30 on the FGA are 4.5 times more likely to be at increased risk of falling (based on the DGI) than those who score >22/30. The metrics of the proposed cutoff score for the FGA (≤22/30) to classify fall risk as determined by scores on the DGI are presented in Table 3A.

Predictive Validity

Seventeen participants (49%) reported 18 falls over the 6 months. Of these, 6 participants (17%) reported 7 unexplained falls. The conditions of the explained falls were medication reaction (n=1), slipping on ice (n=5), ascending stairs or curbs while carrying objects (n=2), moving furniture (n=1), slipping on wet rocks at the beach (n=1), and missing a hidden step behind a door (n=1). No participants sustained a serious injury from a fall or obtained medical attention following a fall. Participants who reported unexplained falls differed significantly from those who did not report unexplained falls in the BBS, TUG, DGI, and the FGA but not in age, sex, height, weight, Mini-Mental State Examination score, or ABC (Tab. 1). Based on their mean scores, the older adults with unexplained falls would be classified as at risk for falls based on the published cutoff scores for the BBS, TUG, FGA, and DGI.

The FGA correctly identified all 6 of the participants who fell in the 6 months following the testing, whereas the TUG identified only 5 participants who fell (83%) and the DGI identified only 4 participants who fell (67%). The ROCs for the FGA, DGI, and TUG versus prospective falls are displayed in Figure 2B. The AUCs were 0.92 for the FGA,

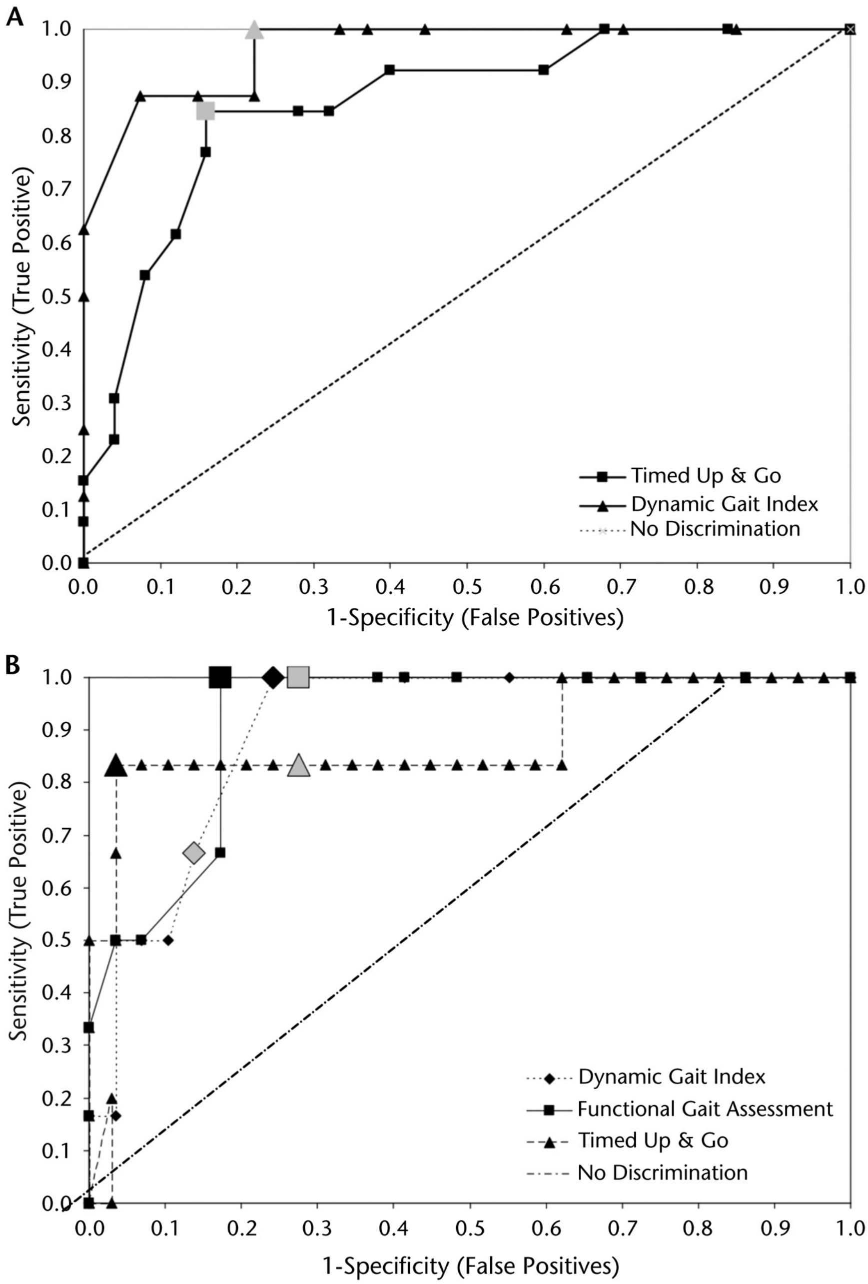

Figure 2.
Receiver operator curve analyses for discriminative and predictive validity of the Functional Gait Assessment (FGA). (A) Receiver operator curve for the FGA's ability to classify fall risk in community-dwelling older adults based on Timed "Up & Go" Test (TUG) (participants with scores of ≥11 s classified as having increased risk for falls)[18,37] and the Dynamic Gait Index (DGI) (participants with scores of <19/24 classified as having increased risk for falls).[24] The area under the curve is 0.87 for the TUG and 0.96 for the DGI. The larger gray points indicate the optimum cutoff score for the FGA of 22/30. (B) The receiver operating curve for the ability of the FGA, TUG, and DGI to predict prospective falls in community-dwelling older adults. The area under the curve is 0.92 for the FGA, 0.91 for the DGI, and 0.89 for the TUG. The larger black points are the optimum cutoff scores for the FGA, DGI and TUG to predict prospective falls. The larger gray points are the proposed cutoff score for the FGA and the published cutoff scores for the DGI and TUG.

Table 2.

Metrics of Individual Scores of the Functional Gait Assessment (FGA) for Classifying Increased Fall Risk[a]

A. Metrics of Individual Scores of the FGA for Classifying Increased Risk of Falls as Determined by Timed "Up & Go" Test Scores of ≥11.0 s

FGA (Abnormal ≤ Score)	Sensitivity	Specificity	LR+	LR−	True Positive	True Negative	False Positive	False Negative
30	100.0%	0.0%	1.00	NaN	13	0	22	0
29	100.0%	18.0%	1.22	0.00	13	4	18	0
28	100.0%	36.0%	1.57	0.00	13	8	14	0
26	92.0%	41.0%	1.56	0.19	12	9	13	1
25	92.0%	64.0%	2.54	0.12	12	14	8	1
24	85.0%	68.0%	2.66	0.23	11	15	7	2
23	85.0%	73.0%	3.10	0.21	11	16	6	2
22	**85.0%**	**86.0%**	**6.21**	**0.18**	**11**	**19**	**3**	**2**
21	77.0%	86.0%	5.64	0.27	10	19	3	3
20	62.0%	86.0%	4.51	0.45	8	19	3	5
19	54.0%	91.0%	5.92	0.51	7	20	2	6
18	31.0%	96.0%	6.77	0.73	4	21	1	9
17	23.0%	96.0%	5.08	0.81	3	21	1	10
15	15.0%	100.0%	NaN	0.85	2	22	0	11
12	8.0%	100.0%	NaN	0.92	1	22	0	12
8	0.0%	100.0%	NaN	1.00	0	22	0	13

B. Metrics of Individual Scores of the FGA for Classifying Increased Fall Risk as Determined by Scores of ≤19 on the Dynamic Gait Index

FGA (Abnormal ≤ Score)	Sensitivity	Specificity	LR+	LR−	True Positive	True Negative	False Positive	False Negative
30	100.0%	0.0%	1.00	NaN	8	0	27	0
29	100.0%	14.8%	1.17	0.00	8	4	23	0
28	100.0%	29.6%	1.42	0.00	8	8	19	0
26	100.0%	37.0%	1.59	0.00	8	10	17	0
25	100.0%	55.6%	2.25	0.00	8	15	12	0
24	100.0%	63.0%	2.70	0.00	8	17	10	0
23	100.0%	66.7%	3.00	0.00	8	18	9	0
22	**100.0%**	**75.8%**	**4.50**	**0.00**	**8**	**21**	**6**	**0**
21	87.5%	75.8%	3.94	0.16	6	21	6	2
20	87.5%	85.2%	5.91	0.15	6	23	4	2
19	87.5%	92.6%	11.81	0.14	6	25	2	2
18	62.5%	100.0%	NaN	0.38	5	27	0	3
16	50.0%	100.0%	NaN	0.50	3	27	0	5
14	25.0%	100.0%	NaN	0.75	2	27	0	6
11	12.5%	100.0%	NaN	0.88	1	27	0	7
8	0.0%	100.0%	NaN	1.00	0	27	0	8

[a] LR+=positive likelihood ratio, LR−=negative likelihood ratio. Optimal cutoff scores are indicated in bold type.

Table 3.
Metrics of the Functional Gait Assessment (FGA) to Classify Increased Risk of Falls and Predict Prospective Falls[a]

A. Metrics of the FGA Using a Cutoff Score of 22/30 to Classify Increased Risk of Falls as Determined by the Timed "Up & Go" Test (TUG) and Dynamic Gait Index (DGI)

	DGI	TUG
Score that indicates increased risk for falls	≤19[24]	≥11 s[37]
FGA criterion score that indicates increased risk for falls	≤22	≤22
Sensitivity	100% (100%–100%)	85% (65%–104%)
Specificity	78% (62%–94%)	86% (72%–101%)
Positive likelihood ratio	4.5 (2.2–9.1)	6.2 (2.1–18.2)
Negative likelihood ratio	0 (0–NaN)	0.2 (0.05–0.6)
Positive predictive value	57% (31%–83%)	79% (57%–100%)
Negative predictive value	100% (100%–100%)	91% (75%–105%)
Odds ratio	∞	35.8
χ^2	5.13 ($P<.001$)	16.66 ($P<.001$)

B. Metrics of Proposed Cutoff Scores for the FGA and Published Cutoff Scores for the DGI and TUG to Predict Prospective Falls in Community-Dwelling Older Adults

	FGA	FGA	DGI	TUG
Score that indicates increased risk for falls	≤20	≤22	≤19[24]	≥11 s[37]
Sensitivity	100% (100%–100%)	100% (100%–100%)	67% (29%–104%)	83% (54%–113%)
Specificity	83% (69%–97%)	72% (56%–89%)	86% (74%–99%)	72% (56%–89%)
Positive likelihood ratio	5.8 (2.6–12.88)	3.6 (2.0–6.5)	4.78 (1.66–14.11)	3.0 (1.5–6.0)
Negative likelihood ratio	0.0 (0–NaN)	0 (0–NaN)	0.4 (0.21–1.21)	0.2 (0–1.4)
Positive predictive value	58% (30%–86%)	43% (17%–69%)	50% (15%–85%)	39% (12%–65%)
Negative predictive value	100% (100%–100%)	100% (100%–100%)	93% (74%–111%)	96% (84%–107%)
Odds ratio	∞	∞	12.5	13.1
χ^2	11.92 ($P<.001$)	10.55 ($P<.001$)	7.67 ($P<.01$)	6.43 ($P<.03$)

[a] Confidence intervals shown in parentheses. NaN=not a number.

0.91 for the DGI, and 0.89 for the TUG. The metrics for various values of the FGA, DGI, and TUG to predict prospective falls are listed in Table 4. The optimum cutoff score for the FGA to identify falls was ≤20/30. The optimum cutoff score for the DGI to identify prospective falls was ≤20/24. The optimum cutoff score for the TUG was ≥12.3 seconds. Metrics for the FGA to predict future falls with cutoff scores of 20 and 22 and for previously established cutoff scores for the DGI and TUG are listed in Table 3B.

Discussion

Although an FGA cutoff score of ≤22/30 provided the optimum metrics to classify fall risk in older adults as identified by scores on the TUG and DGI, an FGA score of ≤20/30 provided the optimum metrics in identifying older adults who sustained unexplained falls in the following 6 months. However, when classifying fall risk in older adults, it is more important to have more false positives than false negatives. The consequences of falsely classifying someone at risk for falling are greater than providing intervention to someone with a lower risk for falls. Although someone may not be at increased risk for falling in the following 6 months, lower scores on the FGA are correlated with slower gait speeds and other measures of imbalance and frailty that may influence a person's mobility and ultimately increase the risk of falling or other consequences of decreased mobility.[8] Providing intervention early may deter some of these complications. Therefore, we propose that clinicians use the more conservative criterion score of ≤22/30 to classify increased risk for falls in older adults.

Table 4.
Metrics of Individual Scores on the Functional Gait Assessment (FGA), Dynamic Gait Index (DGI), and Timed "Up & Go" Test (TUG) for Identifying Prospective Falls in Community-Dwelling Older Adults[a]

A. Metrics of Individual Scores on the FGA for Identifying Prospective Falls in Community-Dwelling Older Adults

FGA (Abnormal ≤ Score)	Sensitivity	Specificity	LR+	LR−	True Positive	True Negative	False Positive	False Negative
30	100.0%	0.0%	1.00	NaN	6	0	29	0
29	100.0%	13.8%	1.16	0.000	6	4	25	0
28	100.0%	27.6%	1.38	0.000	6	8	21	0
26	100.0%	34.5%	1.53	0.000	6	10	19	0
25	100.0%	51.7%	2.07	0.000	6	15	14	0
24	100.0%	58.6%	2.42	0.000	6	17	12	0
23	100.0%	62.1%	2.64	0.000	6	18	11	0
22*	100.0%	72.4%	3.63	0.000	6	21	8	0
21	100.0%	75.9%	4.14	0.000	6	22	7	0
20	**100.0%**	**82.8%**	**5.80**	**0.000**	**6**	**24**	**5**	**0**
19	66.7%	82.8%	3.87	0.403	4	24	5	2
18	50.0%	93.1%	7.25	0.537	3	27	2	3
16	50.0%	96.6%	14.50	0.518	3	28	1	3
14	33.3%	100.0%	NaN	0.667	2	29	0	4
11	16.7%	100.0%	NaN	0.833	1	29	0	5
8	0.0%	100.0%	NaN	1.000	0	29	0	6

B. Metrics of Individual Scores on the DGI for Identifying Prospective Falls in Community-Dwelling Older Adults

DGI (Abnormal ≤ Score)	Sensitivity	Specificity	LR+	LR−	True Positive	True Negative	False Positive	False Negative
24	100.0%	0.0%	1.00	NaN	6	0	29	0
23	100.0%	27.6%	1.38	0.000	6	8	21	0
22	100.0%	44.8%	1.81	0.000	6	13	16	0
21	100.0%	58.6%	2.42	0.000	6	17	12	0
20	**100.0%**	**75.9%**	**4.14**	**0.000**	**6**	**22**	**7**	**0**
19*	66.7%	86.2%	4.83	0.387	4	25	4	2
18	50.0%	89.7%	4.83	0.558	3	26	3	3
17	50.0%	93.1%	7.25	0.537	3	27	2	3
16	50.0%	96.6%	14.50	0.518	3	28	1	3
15	16.7%	96.6%	4.83	0.863	1	28	1	5
11	16.7%	100.0%	NaN	0.833	1	29	0	5
7	0.00%	100.0%	NaN	1.000	0	29	0	6

(Continued)

The prospective falls in this study were divided into explained and unexplained falls. We felt this distinction was necessary, as the follow-up period was only 6 months and environmental conditions would be different for different seasons of the year. Previous studies have considered all participants who fell, participants with injurious falls, or participants with multiple falls. Only one of the older adults in the current study had multiple falls, and no one had injurious falls. Classification of the older adults' falls into explained and unexplained falls seemed reasonable, as many of the circumstances of the participants' explained falls were similar to those that occur in young adults.[42] Other studies that have monitored falls weekly or monthly using a fall cal-

Table 4.
Continued

C. Metrics of Individual Scores on the TUG for Identifying Prospective Falls in Community-Dwelling Older Adults

TUG (Abnormal > Cutoff)	Sensitivity	Specificity	LR+	LR−	True Positive	True Negative	False Positive	False Negative
6.16	100.0%	0.0%	1.00	NaN	6	0	29	0
7.24	100.0%	3.4%	1.04	0.000	6	1	28	0
7.53	100.0%	6.9%	1.07	0.000	6	2	27	0
7.82	100.0%	10.3%	1.12	0.000	6	3	26	0
8.01	100.0%	13.8%	1.16	0.000	6	4	25	0
8.18	100.0%	17.2%	1.21	0.000	6	5	24	0
8.27	100.0%	20.7%	1.26	0.000	6	6	23	0
8.33	100.0%	24.1%	1.32	0.000	6	7	22	0
8.41	100.0%	27.6%	1.38	0.000	6	8	21	0
8.53	100.0%	31.0%	1.45	0.000	6	9	20	0
8.80	100.0%	34.5%	1.53	0.000	6	10	19	0
9.23	100.0%	37.9%	1.61	0.000	6	11	18	0
9.65	83.3%	37.9%	1.34	0.439	5	11	18	1
9.87	83.3%	41.4%	1.42	0.403	5	12	17	1
10.08	83.3%	44.8%	1.51	0.372	5	13	16	1
10.24	83.3%	48.3%	1.61	0.345	5	14	15	1
10.28	83.3%	51.7%	1.73	0.322	5	15	14	1
10.34	83.3%	55.2%	1.86	0.302	5	16	13	1
10.37	83.3%	58.6%	2.01	0.284	5	17	12	1
10.51	83.3%	62.1%	2.20	0.269	5	18	11	1
10.76	83.3%	65.5%	2.42	0.254	5	19	10	1
10.90	83.3%	69.0%	2.69	0.242	5	20	9	1
11.07*	83.3%	72.4%	3.02	0.230	5	21	8	1
11.23	83.3%	75.9%	3.45	0.220	5	22	7	1
11.24	83.3%	79.3%	4.03	0.210	5	23	6	1
11.47	83.3%	82.8%	4.83	0.201	5	24	5	1
11.70	83.3%	86.2%	6.04	0.193	5	25	4	1
11.87	83.3%	89.7%	8.06	0.186	5	26	3	1
12.09	83.3%	93.1%	12.08	0.179	5	27	2	1
12.34	**83.3%**	**96.6%**	**24.17**	**0.173**	**5**	**28**	**1**	**1**
12.62	66.7%	96.6%	19.33	0.345	4	28	1	2
12.84	50.0%	96.6%	14.50	0.518	3	28	1	3
13.22	50.0%	100.0%	NaN	0.500	3	29	0	3
13.97	33.3%	100.0%	NaN	0.667	2	29	0	4
23.35	16.7%	100.0%	NaN	0.833	1	29	0	5
33.23	0.0%	100.0%	NaN	1.000	0	29	0	6

[a] Optimum cutoff scores are in bold type. Current cut scores are indicated with asterisks. NaN=not a number.

endar have shown fall rates similar to those of our study (49% with 1 or more fall),[43,44] which are higher than the fall rates found in other studies.[1–3]

The criterion score recommended for the FGA in classifying fall risk is higher than the mean FGA score found by Walker et al[29] for older adults over 80 years of age. Seven adults over the age of 80 years participated in that study. Their mean FGA score (SD) was 20.7 (5.1). Two of the 7 participants over 80 years of age reported unexplained falls. Their scores were significantly lower than those of the other participants over 80 years of age (scores of 14 and 15). Two of the participants over 80 years of age had FGA scores of <22/30 but did not fall in the ensuing 6 months. However, their FGA scores were within the normative ranges found by Walker et al[29] (95% confidence interval=19.2–22.6). It may be that adults over the age of 80 years have a different criterion score than adults under the age of 80 years. However, Walker et al[29] did not ensure that their participants had clinical balance scores within normal limits, and it is unknown how many of the older adults they tested fell following their testing. Until true normative scores are established, it is safer to use the same criterion score so that all who are at risk for falling are identified.

The FGA identified more of the people who fell in the 6 months after testing than the TUG or DGI. The FGA had a slightly larger AUC than either the DGI or TUG, indicating that the FGA is better at predicting prospective falls. The Sn of the FGA was higher than that of either the DGI or the TUG, although the Sp was lower than that of the TUG, resulting in slightly poorer LR+ and LR− values. The American Geriatrics Society[8] recommendation for the use of the TUG as a screening tool to classify older adults at increased risk for falls based on the metrics of the test and the ease of performance is supported by our research. However, a TUG score of ≥12.3 seconds is the optimum cutoff score for predicting falls in the ensuing 6 months, in agreement with previous research.[18,37] The FGA provides excellent metrics for classify fall risk and predicting future falls.

Clinical tools such as the TUG and BBS have performed inconsistently in classifying older adults at risk for falls.[22,24,26,39,40,45–47] The identification of those at risk for falls appears to be highly dependent on the population of interest, the definition of a fall, and how the prediction is made. Clinicians often emphasize the ability of clinical balance tools to predict future falls or classify people at increased risk of falls. However, these tools also are important in identifying balance impairment and directing treatment. The FGA incorporates timed walking at speeds required to cross a street safely, the ability to walk with head movements, the ability to turn safely, the ability to walk backward, the ability to walk with vision decreased, and the ability to walk with a narrow base of support. All are necessary for daily functional mobility. These tasks may direct specific interventions directed at improving functional gait, such as walking with head turns on various surfaces or providing education on compensation techniques.

The moderate-to-strong correlations between the FGA and the ABC, BBS, and TUG indicate that the FGA provides different information than the other clinical tests and may encompass a more comprehensive measure of balance and the ability to perform various gait tasks. The FGA also has eliminated the ceiling effect demonstrated by the DGI, allowing it to be more sensitive to change.

There were several limitations in the current study. Although an adequate level of power was achieved, a relatively small sample was enrolled. The small sample size did not allow for the discriminative and predictive validity to be evaluated by decade. The study should be repeated with a larger sample size and with people of various impairments and pathologies across the life span. The older adults were followed for only 6 months to determine prospective falls. Collecting data for a longer period of time likely would have increased the number of falls reported and possibly led to a different optimum cutoff score. Further research is needed to determine other psychometric properties of the FGA, such as true normative scores, minimum detectable difference, and minimum clinically important difference.

Conclusion

A cutoff score of 22/30 on the FGA provides optimum validity for classifying fall risk in older adults at risk for falling and in predicting unexplained falls in community-dwelling older adults. The FGA appears to predict falls in community-dwelling older adults better than the currently recommended clinical tools.

Dr Wrisley provided concept/idea/research design, writing, and data analysis. Both authors provided data collection, project management, fund procurement, facilities/equipment, and consultation (including review of manuscript before submission).

This study was approved by the Health Science Institutional Review Board of the University at Buffalo.

This work was supported by New York Physical Therapy Association Research Designated Funds and University at Buffalo's Mark Diamond Research Fund.

This article was received February 26, 2009, and was accepted September 6, 2009.

DOI: 10.2522/ptj.20090069

References

1 Campbell AJ, Borrie MJ, Spears GF, et al. Circumstances and consequences of falls experienced by a community population 70 years and over during a prospective study. *Age Ageing.* 1990;19:136–141.

2 Campbell AJ, Spears GF, Borrie MJ. Examination by logistic regression modelling of the variables which increase the relative risk of elderly women falling compared to elderly men. *J Clin Epidemiol.* 1990;43:1415–1420.

3 Rubenstein LZ, Josephson KR. The epidemiology of falls and syncope. *Clin Geriatr Med.* 2002;18:141–158.

4 Brown AP. Reducing falls in elderly people: a review of exercise interventions. *Physiother Theory Pract.* 1999;15:59–68.

5 Robbins AS, Rubenstein LZ, Josephson KR, et al. Predictors of falls among elderly people: results of two population-based studies. *Arch Intern Med.* 1989;149:1628–1633.

6 Rubenstein LZ, Josephson KR, Robbins AS. Falls in the nursing home. *Ann Intern Med.* 1994;121:442–451.

7 Tinetti ME, Williams TF, Mayewski R. Fall risk index for elderly patients based on number of chronic disabilities. *Am J Med.* 1986;80:429–434.

8 American Geriatrics Society, British Geriatrics Society, and American Academy of Orthopedic Surgeons Panel on Falls Prevention. Guideline for the prevention of falls in older persons. *J Am Geriatr Soc.* 2001;49:664–672.

9 Jarrett PG, Rockwood K, Carver D, et al. Illness presentation in elderly patients. *Arch Intern Med.* 1995;155:1060–1064.

10 Cumming RG, Kelsey JL, Nevitt MC. Methodologic issues in the study of frequent and recurrent health problems: falls in the elderly. *Ann Epidemiol.* 1990;1:49–56.

11 Cummings SR, Nevitt MC, Kidd S. Forgetting falls: the limited accuracy of recall of falls in the elderly. *J Am Geriatr Soc.* 1988;36:613–616.

12 Gillespie LD, Gillespie WJ, Robertson MC, et al. Interventions for preventing falls in elderly people. *Cochrane Database Syst Rev.* 2003;(4):CD000340.

13 Zijlstra GA, van Haastregt JC, van Rossum E, et al. Interventions to reduce fear of falling in community-living older people: a systematic review. *J Am Geriatr Soc.* 2007;55:603–615.

14 Gillespie LD, Robertson MC, Gillespie WJ, et al. Interventions for preventing falls in older people living in the community. *Cochrane Database Syst Rev.* 2009;(2):CD007146.

15 Howe TE, Rochester L, Jackson A, et al. Exercise for improving balance in older people. *Cochrane Database Syst Rev.* 2007;(4):CD004963.

16 Berg K, Wood-Dauphinée S, Williams JI. The Balance Scale: reliability assessment with elderly residents and patients with an acute stroke. *Scand J Rehabil Med.* 1995;27:27–36.

17 Berg KO, Wood-Dauphinée SL, Williams JI, Maki B. Measuring balance in the elderly: validation of an instrument. *Can J Public Health.* 1992;83(suppl 2):S7–S11.

18 Podsiadlo D, Richardson S. The timed "Up & Go": a test of basic functional mobility for frail elderly persons. *J Am Geriatr Soc.* 1991;39:142–148.

19 Shumway-Cook A, Woollacott M. *Motor Control: Theory and Practical Applications* Baltimore, MD: Williams & Wilkins; 2001.

20 Tinetti ME. Performance-oriented assessment of mobility problems in elderly patients. *J Am Geriatr Soc.* 1986;34:119–126.

21 Berg KO, Maki BE, Williams JI, et al. Clinical and laboratory measures of postural balance in an elderly population. *Arch Phys Med Rehabil.* 1992;73:1073–1080.

22 Shumway-Cook A, Brauer S, Woollacott M. Predicting the probability for falls in community-dwelling older adults using the Timed Up & Go Test. *Phys Ther.* 2000;80:896–903.

23 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.

24 Shumway-Cook A, Baldwin M, Polissar NL, Gruber W. Predicting the probability for falls in community-dwelling older adults. *Phys Ther.* 1997;77:812–819.

25 Bogle Thorbahn LD, Newton RA. Use of the Berg Balance Test to predict falls in elderly persons. *Phys Ther.* 1996;76:576–583; discussion 584–575.

26 Riddle DL, Stratford PW. Interpreting validity indexes for diagnostic tests: an illustration using the Berg Balance Test. *Phys Ther.* 1999;79:939–948.

27 Wrisley DM, Walker ML, Echternach JL, Strasnick B. Reliability of the dynamic gait index in people with vestibular disorders. *Arch Phys Med Rehabil.* 2003;84:1528–1533.

28 Wrisley DM, Marchetti GF, Kuharsky DK, Whitney SL. Reliability, internal consistency, and validity of data obtained with the functional gait assessment. *Phys Ther.* 2004;84:906–918.

29 Walker ML, Austin AG, Banke GM, et al. Reference group data for the functional gait assessment. *Phys Ther.* 2007;87:1468–1477.

30 Myers AM, Powell LE, Maki BE, et al. Psychological indicators of balance confidence: relationship to actual and perceived abilities. *J Gerontol A Biol Sci Med Sci.* 1996;51:M37–M43.

31 Powell LE, Myers AM. The Activities-specific Balance Confidence (ABC) Scale. *J Gerontol A Biol Sci Med Sci.* 1995;50:M28–M34.

32 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–M294.

33 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.

34 McConvey J, Bennett SE. Reliability of the Dynamic Gait Index in individuals with multiple sclerosis. *Arch Phys Med Rehabil.* 2005;86:130–133.

35 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.

36 Rose DJ, Jones CJ. Predicting the probability of falls in community-residing older adults using the 8-foot Up-and-Go: a new measure of functional mobility. *J Aging Phys Act.* 2002;10:466–475.

37 Trueblood PR, Hodson-Chennault N, McCubbin A, Youngclarke D. Performance and impairment-based assessments among community dwelling elderly: sensitivity and specificity. *Issues on Aging.* 2001;24:2–6.

38 Lyons SS. Evidence-based protocol: fall prevention for older adults. *J Gerontol Nurs.* 2005;31:9–14.

39 Dibble LE, Lange M. Predicting falls in individuals with Parkinson disease: a reconsideration of clinical balance measures. *J Neurol Phys Ther.* 2006;30:60–67.

40 Nordin E, Lindelof N, Rosendahl E, et al. Prognostic validity of the Timed Up-and-Go test, a modified Get-Up-and-Go test, staff's global judgement and fall history in evaluating fall risk in residential care facilities. *Age Ageing.* 2008;37:442–448.

41 Ganz DA, Higashi T, Rubenstein LZ. Monitoring falls in cohort studies of community-dwelling older people: effect of the recall interval. *J Am Geriatr Soc.* 2005;53:2190–2194.

42 Talbot LA, Musiol RJ, Witham EK, Metter EJ. Falls in young, middle-aged and older community dwelling adults: perceived cause, environmental factors and injury. *BMC Public Health.* 2005;5:86.

43 Russell MA, Hill KD, Blackberry I, et al. The reliability and predictive accuracy of the falls risk for older people in the community assessment (FROP-Com) tool. *Age Ageing.* 2008;37:634–639.

44 Shumway-Cook A, Silver IF, LeMier M, et al. Effectiveness of a community-based multifactorial intervention on falls and fall risk factors in community-living older adults: a randomized, controlled trial. *J Gerontol A Biol Sci Med Sci.* 2007;62: 1420–1427.

45 Botolfsen P, Helbostad JL, Moe-Nilssen R, Wall JC. Reliability and concurrent validity of the Expanded Timed Up-and-Go test in older people with impaired mobility. *Physiother Res Int.* 2008;13:94–106.

46 Muir SW, Berg K, Chesworth B, Speechley M. Use of the Berg Balance Scale for predicting multiple falls in community-dwelling elderly people: a prospective study. *Phys Ther.* 2008;88:449–459.

47 van Iersel MB, Munneke M, Esselink RA, et al. Gait velocity and the Timed-Up-and-Go test were sensitive to changes in mobility in frail elderly patients. *J Clin Epidemiol.* 2008;61:186–191.

Physical Therapy
Journal of the American Physical Therapy Association

Functional Gait Assessment: Concurrent, Discriminative, and Predictive Validity in Community-Dwelling Older Adults

Diane M. Wrisley and Neeraj A. Kumar

PHYS THER. 2010; 90:761-773.
Originally published online April 1, 2010
doi: 10.2522/ptj.20090069