Reliability, Internal Consistency, and Validity of Data Obtained With the Functional Gait Assessment

Background and Purpose. The Functional Gait Assessment (FGA) is a 10-item gait assessment based on the Dynamic Gait Index. The purpose of this study was to evaluate the reliability, internal consistency, and validity of data obtained with the FGA when used with people with vestibular disorders. **Subjects.** Seven physical therapists from various practice settings, 3 physical therapist students, and 6 patients with vestibular disorders volunteered to participate. **Methods.** All raters were given 10 minutes to review the instructions, the test items, and the grading criteria for the FGA. The 10 raters concurrently rated the performance of the 6 patients on the FGA. Patients completed the FGA twice, with an hour's rest between sessions. Reliability of total FGA scores was assessed using intraclass correlation coefficients (2,1). Internal consistency of the FGA was assessed using the Cronbach alpha and confirmatory factor analysis. Concurrent validity was assessed using the correlation of the FGA scores with balance and gait measurements. **Results.** Intraclass correlation coefficients of .86 and .74 were found for interrater and intrarater reliability of the total FGA scores. Internal consistency of the FGA scores was .79. Spearman rank order correlation coefficients of the FGA scores with balance measurements ranged from .11 to .67. **Discussion and Conclusion.** The FGA demonstrates what we believe is acceptable reliability, internal consistency, and concurrent validity with other balance measures used for patients with vestibular disorders. [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.]

Key Words: *Balance; Gait disorders, neurologic; Measurement, applied; Reliability; Validity; Vestibular system.*

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The Dynamic Gait Index (DGI) was developed to assess postural stability during gait tasks in the older adult (greater than 60 years of age) at risk for falling.[1] This scale consists of 8 tasks with varying demands, such as walking at different speeds, walking while turning the head, ambulating over and around obstacles, ascending and descending stairs, and making quick turns. Each item is scored on a 4-level ordinal scale, with a maximum possible score on the entire DGI of 24. A score of 19 or less indicates an increased risk of falling in older adults[2] and in patients with vestibular disorders.[3] The DGI format provides simple patient instructions for performance of every item, with operational definitions for each of the possible grading options.[1] It, however, does not provide

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additional instructions for administering the test or decision rules for scoring items.

Shumway-Cook et al[4] measured the reliability of the DGI using a sample of 5 community-dwelling older adults with varying balance abilities. Five physical therapists who were trained in the administration of the DGI evaluated the subjects' performance on the DGI items. The developer of the test trained the therapists during a 1-hour session in which they were instructed in her unpublished decision rules.[4] Interrater reliability (.96) was found using the ratio of subject variability to total variability. Two therapists repeated the test 1 week later to determine test-retest reliability. Again, using the ratio of subject variability to total variability, test-retest reliability was found to be .98.[4]

The DGI discriminated between people who reported falls and those who did not report falls in both community-dwelling older adults[2] and patients with vestibular disorders.[3] Improvement following physical therapy intervention has been documented using the DGI in older adults[5] and in patients with vestibular disorders.[6–10] The DGI also has been shown to have some concurrent validity (Spearman rank order correlation coefficient [r]=.71, n=70) with the Berg Balance Scale in patients with vestibular disorders.[11]

Dysfunction of the vestibular system may lead to gait abnormalities.[12–14] Several measures, developed to document both the quality of the movement and the temporospatial characteristics of gait, have been applied to the examination of gait in patients with vestibular disorders.[6–9,12,14–21] Of the gait analysis methods that have been used to assess mobility skills in patients with vestibular disorders, one was purely observational,[12] one primarily measures gait speed,[6–9,21] and the others were primarily research tools that are not available to the majority of clinicians.[14–16] None of the tools, in our opinion, were designed to assess the ambulation tasks that patients with vestibular disorders find difficult. The DGI, although not designed specifically for use with patients with vestibular disorders, includes items that are of interest when examining patients with vestibular disorders, and it is easy to administer and requires minimal equipment and space.

Wrisley et al[21] measured the interrater reliability of data obtained with the DGI in patients diagnosed with vestibular disorders by a neurotologist (mean age=62 years, range=21–88) and reported kappa values ranging from .35 to 1.00, with a kappa value of .64 for composite DGI scores. The DGI, when used with patients with vestibular disorders, appears to have a ceiling effect, because the mode of the scores in the study conducted by Wrisley et al[21] was 21. The mean Dizziness Handicap Inventory (DHI) score of these patients, however, was 47,[21] indicating a perception of moderate disability due to their dizziness.[22] Younger people with vestibular disorders often exhibit normal or close to normal DGI scores, although they have self-perceived walking impairments. High DGI scores fail to capture the indications for physical therapy intervention or the risk of falls in these people.[3] We modified the DGI based on the moderate reliability and this potential ceiling effect. We felt that the instructions for the DGI were ambiguous for several of the items, so we attempted to improve the operational definitions and added additional items to challenge patients with vestibular disorders. This revised version is presented as the Functional Gait Assessment (FGA) (Appendix).

The FGA is a 10-item gait test that comprises 7 of the 8 items from the original DGI and 3 new items, including "gait with narrow base of support," "ambulating backwards," and "gait with eyes closed." We added these 3 new items because they have been noted as being difficult in people with vestibular disorders.[23–25] "Gait with eyes closed" is probably the most informative item because the person must rely on vestibular and somatosensory inputs in order to maintain postural control. People without disease have greater head and trunk instability when walking with eyes closed versus walking with eyes open,[26] suggesting that this might be even more difficult for people with vestibular disorders. We judged item 7 from the original DGI ("walking around obstacles") to be of insufficient difficulty to be included in the FGA.[21]

The usefulness of a measurement tool is reliant on the extent to which it can be considered reliable and accurate as an indicator of behavior.[27] Reliability is an indication of the consistency of the measurement. The degree to which an instrument reflects what it is proposed to measure is reflected in validity. Internal consistency is a form of reliability. This property is most relevant to performance measures that consist of multiple items that are to be summarized clinically into a composite score. Clinical inferences made from a composite score of multiple items are strengthened by evidence that all items—in the case of the FGA, dynamic balance—are measuring the same construct.[28] As an index of a test's ability to differentiate among patients, a high degree of internal consistency also supports the use of the instrument as a screening tool.[29] The internal structure of an evaluation tool describes the degree to which the items on the test measure the construct(s) of primary importance.[30] Validation of an instrument requires an accumulation of evidence that supports a strong relationship among test items as well as the degree to which the items conform to the construct on which test score interpretations are based. For tests that

assess multiple dimensions, evidence must be provided that the test items allow meaningful inferences to the patient's performance across these multiple dimensions. Therefore, the purpose of our study was to evaluate the reliability, internal consistency, internal structure validity, and concurrent validity of data obtained with the FGA when used with people with vestibular disorders by examiners without training.

Method

To evaluate the reliability and internal consistency of data obtained with the FGA, 10 raters concurrently (ie, at the same time during the same patient performance) examined the performance of 6 patients with vestibular disorders on the same day. Each patient performed the FGA twice with an hour's rest between tests. Each patient completed the DHI and the Activities-specific Balance Confidence (ABC) Scale, rated his or her perception of dizziness symptoms (PDS) on a verbal analog scale, and reported the number of falls during the previous 4 weeks. Following completion of both trials of the FGA, each patient performed the DGI and the Timed "Up & Go" Test (TUG) and stood on viscoelastic foam with eyes closed. The entire session took approximately 2 hours to complete.

Subjects

A convenience sample of 7 physical therapists from various practice settings and 3 physical therapist students from the University of Pittsburgh (mean age=33.6 years, SD=8.4; 2 men and 8 women) volunteered to participate as raters. Physical therapists and physical therapist students were asked to participate, with a goal of having 10 raters with a variety of practice settings and experience levels. Physical therapist students who had completed course work relevant to the evaluation and management of vestibular disorders were considered eligible as raters. Physical therapist raters had to have a valid Pennsylvania physical therapist license. Only one person who was asked to participate declined because of prior commitments. The physical therapists had between 0 and 21 years of practice experience ($\overline{X}$=10.0, SD=8.6). One physical therapist student had completed the first year of the 2-year Master of Physical Therapy (MPT) degree program, and the other 2 physical therapist students were nearing the completion of their second year of the 2-year MPT program. A sample size of 10 raters was used because of concerns about accurately visualizing and scoring the subject during the administration of the FGA. Descriptive information regarding the physical therapists is provided in Table 1.

Six patients with vestibular disorders (mean age=58.7 years, SD=12.4) who had previously received or were currently receiving physical therapy at the Centers for Rehab Services, Balance and Vestibular Clinic, Pitts-

burgh, Pa, with a duration of symptoms ranging from 3 to 120 months ($\overline{X}$=46.2, SD=48.1), volunteered as subjects. We attempted to obtain a broad distribution of patient ages, vestibular diagnoses, and impairment levels. The subjects met the following inclusion criteria: (1) the ability to follow 3-step commands, (2) the ability to provide informed consent, (3) the ability to ambulate 6 m (20 ft) without human assistance, and (4) the ability to tolerate the gait tasks without an excessive increase in fatigue or dizziness. Descriptive information regarding the patients is provided in Table 2. All subjects provided informed consent.

Procedure

All physical therapists were provided with the FGA and written instructions for administering the test concurrently. The physical therapists and physical therapist students were given 10 minutes to review the test items, grading criteria, and instructions for administering the test. They were instructed not to discuss the grading criteria or the test with other raters. This procedure was used in an effort to enhance the generalizabilty of the results to the practicing physical therapist. By specifically not performing more extensive training of the raters or allowing them to discuss decision rules among themselves, we felt we could better determine if the tool could be used by physical therapists in the clinic without prior training. The 10 raters were asked to concurrently rate the 6 patients on the FGA. Instructions on how to do the elements of the FGA (as shown in the Appendix) were given to all patients by a physical therapist (DMW), who was not one of the 10 raters. Patients completed the FGA in a large open area with a 6-m (20-ft) walkway marked off, and markings as directed in the FGA instructions (Figure). The physical therapist raters were positioned at equal intervals along both sides of the walkway, at least 0.3 m (1 ft) outside the markings (Figure). The raters remained in the same position throughout the testing. Four physical therapists had stopwatches. Patients completed the FGA twice, with an hour's rest between sessions.

To help describe the concurrent validity of data obtained with the FGA, we used several balance and gait measurement tools commonly used in vestibular rehabilitation clinics. Several balance assessment tools were used because there is no commonly accepted "gold standard" to measure balance function in patients with vestibular disorders. One of the authors who had not participated in the scoring of the FGA (SLW) administered these tests immediately following administration of the second FGA. The additional tests took approximately 10 to 15 minutes to complete. The examiner (SLW) did not note any fatigue, although one subject stated that she was dizzier than when she arrived for testing.

Table 1.
Descriptive Information for the Physical Therapists Conducting the Examination of Patients With Vestibular Disorders Using the Functional Gait Assessment[a]
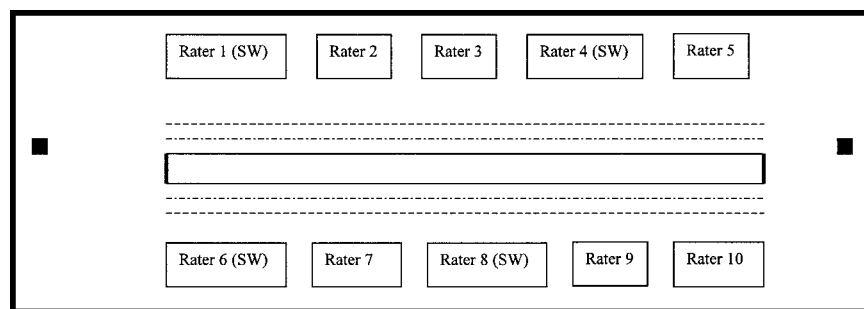
	Therapist									
	1	2	3	4	5	6	7	8	9	10
Age (y)	43	30	42	36	40	25	24	22	30	44
Sex	F	F	F	F	F	F	F	M	F	M
Physical therapy degree	Certificate	MSPT	BS	BS	BS	MPT	MPT	MPT	MPT	BS
Highest degree	MS	MSPT	MS	MS	MS	MPT	MPT	BS	MS	BS
Current practice	Academics	Home care	Home care	Acute and outpatient	Outpatient	New graduate	New graduate	Physical therapist student	Neurologic acute care	Outpatient
Specialty certification	NCS	None	None	NCS	None	None	None	None	None	None
Previous experience with DGI	Yes	Yes	No	Yes	Yes	No	No	No	Yes	Yes
No. of years practicing physical therapy	20	6	21	15	18	0	0	0	6	14
No. of years practicing in each treatment environment										
Acute care	4	2	9	4	1	0	0	0	6	0
Inpatient rehabilitation	13	1	3	5	1	0	0	0	2	2
Outpatient rehabilitation	0	0	8	6	1	0	0	0	0	12
Skilled nursing facility	0	0	0	0	0	0	0	0	0	1
Home health	0	2	1	1	1	1	0	0	0	1
Outpatient orthopedic	0	0	0	0	17	0	0	0	0	0
Vestibular rehabilitation	2	2	0	7	15	0	0	0	2	2
Managing patients with neurological disorders	20	1	21	15	18	0	0	0	6	0

[a] M=male, F=female, DGI=Dynamic Gait Index, NCS=neurologic certified specialist, BS=Bachelor of Science degree, MS=Master of Science degree, MPT=Master of Physical Therapy degree, MSPT=Master of Science in Physical Therapy degree.

Table 2.
Descriptive Information on Patients Who Underwent the Functional Gait Assessment (FGA)[a]

| | Subject | | | | | |
	1	2	3	4	5	6
Age (y)	71	68	42	69	47	55
Sex	F	F	F	F	F	F
Diagnosis	PVD	PVD	LC	PVD	LC	LC
Currently undergoing vestibular rehabilitation	No	Yes	Yes	Yes	No	No
DHI score	48	12	38	52	88	38
ABC score	89	68	49	45	13	68
PDS	0	55	0	50	60	0
Falls (no. in previous 4 wk)	0	0	0	0	4	0
Duration (mo)	24	7	3	120	91	32
Foam–eyes closed (30 s maximum)	22	NT	2	2	NT	2
TUG(s)	7.7	10.2	8.5	9.6	NT	9.7
DGI	23	20	22	19	NT	21
SMD	30	0	20	65	100	40
FGA	24	24	26	15	9	22

[a] DHI=Dizziness Handicap Inventory, ABC=Activities-specific Balance Confidence Scale, PDS=perception of dizziness symptoms, TUG=Timed "Up & Go" Test, DGI=Dynamic Gait Index, SMD=space and motion discomfort, PVD=peripheral vestibular disorders, LC=labyrinthine concussion, NT=not tested.

Figure.
Setup of walkway and walkway markings, plus the position of the physical therapist raters for administration of Functional Gait Assessment. ——=lines outlining 30.48-cm (12-in) walkway, - - - - -=15.24-cm (6-in) lines outside walkway, - - - - - -=25.4-cm (10-in) lines outside walkway, ■=cones indicating starting and stopping points, I=timing starting and ending points, SW=physical therapist used stopwatch during the test.

Following the second administration of the FGA, the original DGI[1] and the TUG[31] were administered to the patients, and they were timed standing on foam with their eyes closed. The TUG[31] quantifies the speed at which a person is able to stand, walk 3 m, turn, walk back, and sit down. The TUG has been used previously to measure gait in people with vestibular disorders.[8,17] Podsiadlo and Richardson[31] reported an intraclass correlation coefficient (ICC [2,1]) for test-retest reliability of .99 in 60 people with stroke, Parkinson disease, arthritis, and other comorbid conditions. Scores of 13.5 seconds and above on the TUG indicate an increased risk of falling in older adults.[32] The TUG was included as a reference measure because it is a gait measure used in

clinical practice to discriminate fallers from nonfallers and has been used previously with people with vestibular disorders.

Patients were asked to stand on medium-density viscoelastic foam (60 × 45 × 18 cm) with their feet touching, arms across their chest, and eyes closed. Standing on foam with the eyes closed was included because it is a clinical measure of the ability to use sensory information for balance. Good test-retest reliability of standing on foam with eyes closed has been reported in 26 young adults (ICC [2,1]=.99)[33] and in 10 older adults (ICC [2,1]=.75).[34] The timing began when the patients closed their eyes and continued until they opened their eyes, moved their arms or feet from the starting position, or achieved the maximum score of 30 seconds. Standing on the foam with eyes closed is considered to be condition 5 of the Clinical Test of Sensory Integration and Balance.[35,36] Failure to successfully stand on a foam pad has been related to increased falls risk in older people.[34]

Patients also were asked to complete the DHI[37] and the ABC Scale,[38] report their number of falls in the previous 4 weeks, rate their symptoms of space and motion discomfort[39] on a verbal analog scale of 0 (no symptoms) to 100 (worst imaginable symptoms), and rate their PDS on a verbal analog scale of 0 (no symptoms) to 100 (worst imaginable symptoms). The DHI, ABC, perceived symptoms of space and motion discomfort, and PDS were included as reference measures because they are means of measuring a person's perception of dizziness and the impact it has on his or her function.

The DHI is a self-assessment tool used to rate a patient's perception of disability from his or her dizziness.[37] The test-retest reliability of data obtained with the DHI has been reported in 106 people with vestibular disorders to be reflected in a Spearman correlation coefficient (r) of .97.[37] The scale runs from 0 (no perceived handicap) to 100 (severe perceived handicap). Higher scores on the DHI indicate greater handicap. The DHI has been shown to yield reliable and valid measurements in patients with vestibular disorders.[37] Patients completed

Table 3.
Intrarater and Interrater Reliability for Individual and Total Functional Gait Assessment (FGA) Items

| | FGA Item | | | | | | | | | | |
	1	2	3	4	5	6	7	8	9	10	Total
Intrarater reliability											
% agreement	90	72	58	57	63	83	50	40	67	86	67
Kappa	.83	.55	.38	.37	.37	.69	.30	.16	.49	.64	.50
Interrater reliability											
% agreement	88	60	58	68	60	68	66	66	67	90	58
Kappa	.78	.37	.40	.53	.34	.41	.45	.46	.54	.76	.50

the ABC as a means of evaluating their confidence in performing 16 activities of daily living.[38] The ABC has demonstrated test-retest reliability, with a Spearman correlation coefficient (r) of .92 over a 2-week period in 60 community-dwelling older adults[38] and in 50 people with lower-limb amputations (ICC [2,1]=.91).[40] Scores on the ABC range from 0, indicating no confidence, to 100, indicating complete confidence in the patient's ability to complete the task without losing their balance.[38] The ABC has been used previously with people with vestibular disorders, and ABC scores were shown to be moderately correlated with DHI scores in people with complaints of dizziness.[41]

Data Analysis

Intrarater and interrater reliability of the total FGA score were determined using the ICC (2,1).[42] Intrarater and interrater agreement (between sessions and between raters) for individual FGA items and the FGA total were determined using the kappa statistic. For between-rater agreement, the mean kappa across all 45 rater pairs was determined by the first administration for each subject. For individual FGA item scores, only absolute agreement was considered for kappa analysis. For the total FGA, scores that agreed within 2 points were considered to be in absolute agreement for kappa analysis.

Internal consistency, or the homogeneity, of items included in the FGA was determined using the Cronbach alpha. This assessment was performed across both testing sessions and within each of the tests.

Internal structure validity[30,43] of data obtained with the FGA was examined using exploratory factor analysis with the principal component extraction method to examine the range of dimensions being measured. The loading of each FGA item on the derived factors was used to determine the amount of variance accounted for by each factor. This analysis also helped to determine weak items that could possibly be dropped from the FGA for subsequent analysis and to describe possible subscale measures that could be derived.

Concurrent validity of data obtained with the FGA was assessed by calculating correlations between balance measures and the FGA. The Pearson product moment correlation coefficient was calculated between the FGA and the TUG and between the FGA and standing on foam with eyes closed. The Spearman rank order correlation coefficient was calculated between the FGA and the DHI, ABC, PDS, DGI, and reported number of falls.

Results

Intrarater Reliability

Intrarater reliability of the total FGA scores was reflected by an ICC of .83. Agreement between the 2 trials consisted of 60 possible agreements (10 clinicians evaluating 6 patients) for each FGA item and total FGA. Table 3 contains the percentage of agreement (out of 60 possible) and the kappa value for each item and the total FGA score. Kappa values, indicating test-retest agreement, were, in our opinion, below the moderate range (fair to poor) as described by Landis and Koch[44] for items 3 ("gait with horizontal head turns"), 4 ("gait with vertical head turns"), 5 ("gait and pivot turn"), 7 ("gait with narrow base of support"), and 8 ("gait with eyes closed").

Interrater Reliability

Interrater reliability of the total FGA scores was reflected by an ICC of .84. Agreement was determined among 10 clinicians who measured 6 patients on the first measurement trial. As there are 45 possible clinician pair agreements per subject, 6 subjects created 270 possible agreements for each FGA item and the total FGA scores. Table 3 contains percentages of agreement and kappa values for each item and total FGA scores. Values in Table 3 represent mean agreement and kappa across the 45 clinician pairs for each item. Mean test-retest agreement across all clinician pairs, in our opinion, was moderate or better for all items except items 2 ("change in gait speed") and 4 ("gait with vertical head turns").

Table 4 contains ICC values for interrater reliability of total FGA scores on the first measurement trial for each

Table 4.
Interrater Reliability on Total Functional Gait Assessment (FGA) Trial 1: Intraclass Correlation Coefficients (ICCs) for Each Therapist Rater Pair[a]

Therapist	1	2	3	4	5	6	7	8	9
2	.94								
3	.76	.89							
4	.85	.87	.86						
5	.81	.84	.87	.99					
6	.91	.92	.88	.96	.93				
7	.78	.89	.99	.89	.89	.90			
8	.60	.76	.94	.84	.86	.81	.95		
9	.90	.84	.82	.92	.90	.91	.84	.69	
10	.99	.91	.76	.83	.79	.89	.77	.58	.92

[a] Note that raters 1 and 10 and raters 5 and 6 were diagonally across from each other, yet they had ICCs of .99 and .93, respectively. The rater pairs with ICC values of less than .7—raters 8 and 10, 8 and 9, and 8 and 1—were positioned near one another.

Table 5.
Factor Loading Values and Loading of Items That Exceeded .3[a]

FGA Item	Factor 1	Factor 2	Factor 3	Communality
1	.86			.86
2	.80			.70
3	.72		.39	.75
4	.80	.32		.80
5	.67			.47
6	.86			.74
7			.84	.85
8		.60		.42
9	.61	−.60		.74
10		.84		.76

[a] The associations (>.30) between each item and 3 extracted factors of the Functional Gait Assessment (FGA) are displayed. Communalities describe the proportion of variance in item responses accounted for by the 3 factors.

of the 45 therapist pairs. The position of the therapist did not appear to make a difference in interrater reliability because the rater pairs at opposite ends of the walkway (rater 1 versus rater 10 and rater 5 versus rater 6) demonstrated ICCs of .99 and .93. Surprisingly, the 3 rater pairs with ICC values of less than .7 (rater 8 versus rater 10, rater 8 versus rater 9, and rater 8 versus rater 1) all involved pairs positioned close to each other on the walkway.

Internal Consistency
The FGA demonstrated internal consistency within and across both FGA test trials for each patient. Cronbach alpha values were .81 and .77 for individual trials 1 and 2, respectively. The Cronbach alpha was .79 across both trials. Item-to-corrected item correlations ranged from .12 to .80 across both administrations. In both testing administrations, items 7 ("gait with narrow base of support"), 8 ("gait with eyes closed"), and 10 ("steps") demonstrated the weakest correlations with total FGA score, ranging from .12 to .31.

Internal Structure Validity
Principal components factor analysis[45,46] demonstrated individual FGA item loading across 3 extracted factors that may represent separate domains of performance on the total battery. This 3-factor solution accounted for 69% and 66% inter-item variance in trials 1 and 2, respectively. The factor loading values and loading of individual FGA items that exceeded .3 across both test administrations are displayed in Table 5.

The factor loading values can be numbers ranging from −1 to +1 and can be interpreted as the correlation of the FGA item with the factor. The communality values in Table 5 for each item are the sum of the squared loading values for each factor. This communality value can be interpreted as the portion of individual item variance

explained by the 3 extracted factors. The sum of the squared loading values for each factor (eigenvalue) represents the total amount of variance explained by a factor. The 3 factors with eigenvalues greater than 1 (or 10% of the variance) extracted from the FGA item analysis accounted for 71% of the variance in the FGA (42%, 18%, and 11% for factors 1, 2, and 3, respectively).

From inspection of the loading values in Table 5, it is possible to identify that FGA items 1 through 6 are closely related to factor 1, item 7 is related to factor 3, and items 8 and 10 are related to factor 2. Item 9 displays peculiar properties of a positive relationship with factor 1 and an equally strong negative relationship with factor 2.

Concurrent Validity
Correlation coefficients for the relationships among the FGA, the original DGI, and measures of balance are listed in Table 6. The FGA scores were correlated with the ABC Scale scores ($r=.64$), DHI scores ($r=-.64$), PDS scores ($r=-.70$), number of falls ($r=-.66$), TUG scores ($r=-.50$), and DGI scores ($r=.80$).

Discussion
The FGA demonstrated what we would consider moderate reliability when used by physical therapists of varying experience levels with patients with vestibular disorders; however, because of the use of concurrent observations, error resulting from patient variability was eliminated. This could have affected the reliability estimate. The reliability of data obtained with this revised version of the DGI was similar to that found with the original DGI in patients with vestibular disorders[21] and lower than that found with the original DGI in older adults at risk for falling when the raters were trained by the developer of the test.[4]

Table 6.
Patients' Performance on Measures of Balance and the Correlation of the Functional Gait Assessment With the Balance Measures Using the Spearman Rank Order Correlation Coefficient

	Descriptive Information			Correlation (r) With Functional Gait Assessment
	$\overline{X}$	SD	Range	
Perception of dizziness symptoms	27.5	30.3	0–60	−.70
Dizziness Handicap Inventory	46.0	24.9	12–88	−.64
Activities-specific Balance Confidence Scale	55.3	26.1	13–89	.64
No. of falls in previous 4 wk	No falls: 5 patients 4 falls: 1 patient			−.66
Timed "Up & Go" Test(s)	9.13	10.3	7.7–10.19	−.50
Foam–eyes closed (s)	6.75	9.94	1.67–21.67	.11
Dynamic Gait Index	21.0	1.6	19–23	.80
Functional Gait Assessment	20.0	6.6	9–26	1.0

There are several reasons why we expected that the FGA would yield better reliability values than the original DGI, including the inclusion of therapists experienced with use of the DGI as raters and the revised patient instructions and grading criteria in the FGA. Sixty percent of the physical therapists who participated in our study had experience using the original DGI. We expected that the physical therapists who had previously used the DGI would demonstrate more reliability in scoring the FGA than physical therapists who had not previously used the DGI. There was no difference, however, in test-retest reliability of the total FGA scores between clinicians who were experienced or inexperienced in using the DGI (ICC=.84 versus ICC=.86). The revised patient instructions and grading criteria in the FGA did not appear to improve the reliability of data obtained with the DGI. The difficulty may be more in the absence of published decision rules for both the DGI and FGA than in the grading criteria.

The minimal training and the stationary viewing fields of the raters may have led to lower reliability than expected or would be seen in the clinic, but the concurrent observations may have inflated reliability estimates. The lack of instruction for the raters was intentional because the purpose of our study was to evaluate the reliability of data obtained with the FGA if it was used in the clinic without instruction. The physical therapists were provided with the test items and the grading criteria only 10 minutes before the start of the study and were not permitted to discuss the grading criteria with the other physical therapists to establish decision rules. The reliability may have been greater if the therapists had been instructed in administering the test by one of the developers and were provided with the opportunity to develop decision rules. The physical therapists were scattered on either side of the walkway and maintained the same position during all testing. The different

vantage points of the physical therapists or their lack of mobility may have influenced their scoring.

Interrater and intrarater reliability of data obtained with the FGA were similar in this study. We might have expected higher intrarater reliability than interrater reliability, because a physical therapist would use similar decision rules when scoring the test. The intrarater reliability may have been lowered because the test was administered live, with the patients completing the test twice. Patient variability, therefore, may have been a factor.

Intrarater reliability was especially low ($\kappa \leq .40$) on items 3 ("gait with horizontal head turns"), item 4 ("gait with vertical head turns"), item 5 ("gait and pivot turn"), item 7 ("gait with narrow base of support"), and item 8 ("gait with eyes closed"). These items are thought to be the most difficult for patients with vestibular disorders to perform and, therefore, may have shown the greatest change in the second trial. Interrater reliability was similar for trial 1 versus trial 2 suggesting that the lower intrarater reliability was because differences in patient performance.

The items with the lowest interrater reliability were items 2 ("change in gait speed") and 5 ("gait and pivot turn"). Although item 2 provides criteria to define gait impairment by indicating acceptable amounts of sway, patients may stay within the sway parameters and still appear unstable, tempting physical therapists to give a lower score for that item. Physical therapists, in our opinion, appear to be reluctant to assign a normal score to a patient's performance unless the patient looks normal despite the fact that the patient meets the grading criteria. This was evident to us, especially on item 10 ("steps"). A few physical therapists assigned lower scores to patients who ascended and descended the stairs

without a railing but did not appear completely steady. Item 5 ("gait and pivot turn") uses a time criterion to differentiate between performance levels. The lower interrater reliability may be because only 4 of the physical therapists had stopwatches or may be the result of the physical therapists' hesitation to give higher scores if the patient appeared unsteady.

The second goal of our revising the DGI was to eliminate the ceiling effect when the test is used with patients with vestibular disorders. The range of scores of the patients on the original DGI in our study was 19 to 23, with a mean of 21 (SD=1.6). The range of scores on the FGA was 9 to 26, with a mean of 20 (SD=6.6). The range of scores on the FGA more closely resembles the distribution on the ABC Scale and the DHI and appears to have eliminated the ceiling effect that was seen when the DGI was used in this group of patients with vestibular disorders. Further research is needed to determine whether the FGA is sensitive to change during rehabilitation as well as to determine normative ranges of the scores and the predictive value of the FGA.

The FGA demonstrated adequate individual item-to-total score consistency. From this property of item homogeneity, we determined that all items appear to be measuring the same construct—functional gait performance. The items displaying the lowest correlations with total FGA scores (items 7, 8, and 10) would appear to provide useful functional information to the clinician despite their apparent lack of homogeneity with the main construct. Because of this apparent utility, these items will be kept in the analysis pending further evaluation from future clinical studies.

Results of the principal component analysis for the FGA support the notion that functional performance of gait activities is composed of 3 separate dimensions. A minimum of 70% of the variation for 8 items was accounted for by the 3 factors. Further study is warranted with diverse subpopulations before the homogeneity of FGA test items can be conclusively determined.

The final point to be made regarding the principal component analysis is the problem of factor interpretation. Items 7, 8, and 10 are strongly associated with dimensions that are separate from items 1 through 6 and 9. Ideally, it should be possible to identify the basis for these dimensional distinctions. Items 7, 8, and 10 represent a greater degree of functional difficulty. This is consistent with the intent in test development to reduce the ceiling effect often seen with the DGI. The difficulty in explaining the factors underlying the FGA from this small preliminary sample warrants future study with diverse populations.

The FGA demonstrated moderate correlation with the DHI, ABC Scale, PDS, number of falls, and the original DGI. This moderate correlation indicates that the FGA has concurrent validity with the measures of balance but that it is also measuring different components of balance. Further research is needed to assess concurrent and predictive validity of data obtained with the FGA in patients with vestibular disorders using a larger sample size, with special consideration given to the items added to the FGA that were not included in the original DGI.

Conclusions

The FGA is a modification of the DGI that uses higher-level gait tasks to increase the applicability of the test to people with vestibular disorders and to eliminate the ceiling effect of the original test. The FGA demonstrates similar reliability to the DGI even when administered without training by the test developers, and it demonstrates what we would consider acceptable reliability and validity for use as a clinical gait measure for patients with vestibular disorders. Further research, however, is needed to determine the appropriate instructions and decision rules that should be provided with the test and to determine the clinical usefulness and predictive value of specific scores.

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Appendix.

Functional Gait Assessment[a]

Requirements: A marked 6-m (20-ft) walkway that is marked with a 30.48-cm (12-in) width.

____ **1. GAIT LEVEL SURFACE**

Instructions: *Walk at your normal speed from here to the next mark (6 m [20 ft]).*

Grading: Mark the highest category that applies.

(3) Normal—Walks 6 m (20 ft) in less than 5.5 seconds, no assistive devices, good speed, no evidence for imbalance, normal gait pattern, deviates no more than 15.24 cm (6 in) outside of the 30.48-cm (12-in) walkway width.

(2) Mild impairment—Walks 6 m (20 ft) in less than 7 seconds but greater than 5.5 seconds, uses assistive device, slower speed, mild gait deviations, or deviates 15.24–25.4 cm (6–10 in) outside of the 30.48-cm (12-in) walkway width.

(1) Moderate impairment—Walks 6 m (20 ft), slow speed, abnormal gait pattern, evidence for imbalance, or deviates 25.4–38.1 cm (10–15 in) outside of the 30.48-cm (12-in) walkway width. Requires more than 7 seconds to ambulate 6 m (20 ft).

(0) Severe impairment—Cannot walk 6 m (20 ft) without assistance, severe gait deviations or imbalance, deviates greater than 38.1 cm (15 in) outside of the 30.48-cm (12-in) walkway width or reaches and touches the wall.

____ **2. CHANGE IN GAIT SPEED**

Instructions: *Begin walking at your normal pace (for 1.5 m [5 ft]). When I tell you "go," walk as fast as you can (for 1.5 m [5 ft]). When I tell you "slow," walk as slowly as you can (for 1.5 m [5 ft]).*

Grading: Mark the highest category that applies.

(3) Normal—Able to smoothly change walking speed without loss of balance or gait deviation. Shows a significant difference in walking speeds between normal, fast, and slow speeds. Deviates no more than 15.24 cm (6 in) outside of the 30.48-cm (12-in) walkway width.

(2) Mild impairment—Is able to change speed but demonstrates mild gait deviations, deviates 15.24–25.4 cm (6–10 in) outside of the 30.48-cm (12-in) walkway width, or no gait deviations but unable to achieve a significant change in velocity, or uses an assistive device.

(1) Moderate impairment—Makes only minor adjustments to walking speed, or accomplishes a change in speed with significant gait deviations, deviates 25.4–38.1 cm (10–15 in) outside the 30.48-cm (12-in) walkway width, or changes speed but loses balance but is able to recover and continue walking.

(0) Severe impairment—Cannot change speeds, deviates greater than 38.1 cm (15 in) outside 30.48-cm (12-in) walkway width, or loses balance and has to reach for wall or be caught.

____ **3. GAIT WITH HORIZONTAL HEAD TURNS**

Instructions: *Walk from here to the next mark 6 m (20 ft) away. Begin walking at your normal pace. Keep walking straight; after 3 steps, turn your head to the right and keep walking straight while looking to the right. After 3 more steps, turn your head to the left and keep walking straight while looking left. Continue alternating looking right and left every 3 steps until you have completed 2 repetitions in each direction.*

Grading: Mark the highest category that applies.

(3) Normal—Performs head turns smoothly with no change in gait. Deviates no more than 15.24 cm (6 in) outside 30.48-cm (12-in) walkway width.

(2) Mild impairment—Performs head turns smoothly with slight change in gait velocity (eg, minor disruption to smooth gait path), deviates 15.24–25.4 cm (6–10 in) outside 30.48-cm (12-in) walkway width, or uses an assistive device.

(1) Moderate impairment—Performs head turns with moderate change in gait velocity, slows down, deviates 25.4–38.1 cm (10–15 in) outside 30.48-cm (12-in) walkway width but recovers, can continue to walk.

(0) Severe impairment—Performs task with severe disruption of gait (eg, staggers 38.1 cm [15 in] outside 30.48-cm (12-in) walkway width, loses balance, stops, or reaches for wall).

____ **4. GAIT WITH VERTICAL HEAD TURNS**

Instructions: *Walk from here to the next mark (6 m [20 ft]). Begin walking at your normal pace. Keep walking straight; after 3 steps, tip your head up and keep walking straight while looking up. After 3 more steps, tip your head down, keep walking straight while looking down. Continue alternating looking up and down every 3 steps until you have completed 2 repetitions in each direction.*

Grading: Mark the highest category that applies.

(3) Normal—Performs head turns with no change in gait. Deviates no more than 15.24 cm (6 in) outside 30.48-cm (12-in) walkway width.

(2) Mild impairment—Performs task with slight change in gait velocity (eg, minor disruption to smooth gait path), deviates 15.24–25.4 cm (6–10 in) outside 30.48-cm (12-in) walkway width or uses assistive device.

(1) Moderate impairment—Performs task with moderate change in gait velocity, slows down, deviates 25.4–38.1 cm (10–15 in) outside 30.48-cm (12-in) walkway width but recovers, can continue to walk.

(0) Severe impairment—Performs task with severe disruption of gait (eg, staggers 38.1 cm [15 in] outside 30.48-cm (12-in) walkway width, loses balance, stops, reaches for wall).

____ **5. GAIT AND PIVOT TURN**

Instructions: *Begin with walking at your normal pace. When I tell you, "turn and stop," turn as quickly as you can to face the opposite direction and stop.*

Grading: Mark the highest category that applies.

(3) Normal—Pivot turns safely within 3 seconds and stops quickly with no loss of balance.

(2) Mild impairment—Pivot turns safely in >3 seconds and stops with no loss of balance, or pivot turns safely within 3 seconds and stops with mild imbalance, requires small steps to catch balance.

(1) Moderate impairment—Turns slowly, requires verbal cueing, or requires several small steps to catch balance following turn and stop.

(0) Severe impairment—Cannot turn safely, requires assistance to turn and stop.

____ **6. STEP OVER OBSTACLE**

Instructions: *Begin walking at your normal speed. When you come to the shoe box, step over it, not around it, and keep walking.*

Grading: Mark the highest category that applies.

(3) Normal—Is able to step over 2 stacked shoe boxes taped together (22.86 cm [9 in] total height) without changing gait speed; no evidence of imbalance.

(2) Mild impairment—Is able to step over one shoe box (11.43 cm [4.5 in] total height) without changing gait speed; no evidence of imbalance.

(1) Moderate impairment—Is able to step over one shoe box (11.43 cm [4.5 in] total height) but must slow down and adjust steps to clear box safely. May require verbal cueing.

(0) Severe impairment—Cannot perform without assistance.

(Continued)

_____**7. GAIT WITH NARROW BASE OF SUPPORT**

Instructions: _Walk on the floor with arms folded across the chest, feet aligned heel to toe in tandem for a distance of 3.6 m [12 ft]. The number of steps taken in a straight line are counted for a maximum of 10 steps._
Grading: Mark the highest category that applies.
- (3) Normal—Is able to ambulate for 10 steps heel to toe with no staggering.
- (2) Mild impairment—Ambulates 7–9 steps.
- (1) Moderate impairment—Ambulates 4–7 steps.
- (0) Severe impairment—Ambulates less than 4 steps heel to toe or cannot perform without assistance.

_____**8. GAIT WITH EYES CLOSED**

Instructions: _Walk at your normal speed from here to the next mark (6 m [20 ft]) with your eyes closed._
Grading: Mark the highest category that applies.
- (3) Normal—Walks 6 m (20 ft), no assistive devices, good speed, no evidence of imbalance, normal gait pattern, deviates no more than 15.24 cm (6 in) outside 30.48-cm (12-in) walkway width. Ambulates 6 m (20 ft) in less than 7 seconds.
- (2) Mild impairment—Walks 6 m (20 ft), uses assistive device, slower speed, mild gait deviations, deviates 15.24–25.4 cm (6–10 in) outside 30.48-cm (12-in) walkway width. Ambulates 6 m (20 ft) in less than 9 seconds but greater than 7 seconds.
- (1) Moderate impairment—Walks 6 m (20 ft), slow speed, abnormal gait pattern, evidence for imbalance, deviates 25.4–38.1 cm (10–15 in) outside 30.48-cm (12-in) walkway width. Requires more than 9 seconds to ambulate 6 m (20 ft).
- (0) Severe impairment—Cannot walk 6 m (20 ft) without assistance, severe gait deviations or imbalance, deviates greater than 38.1 cm (15 in) outside 30.48-cm (12-in) walkway width or will not attempt task.

_____**9. AMBULATING BACKWARDS**

Instructions: _Walk backwards until I tell you to stop._
Grading: Mark the highest category that applies.
- (3) Normal—Walks 6 m (20 ft), no assistive devices, good speed, no evidence for imbalance, normal gait pattern, deviates no more than 15.24 cm (6 in) outside 30.48-cm (12-in) walkway width.
- (2) Mild impairment—Walks 6 m (20 ft), uses assistive device, slower speed, mild gait deviations, deviates 15.24–25.4 cm (6–10 in) outside 30.48-cm (12-in) walkway width.
- (1) Moderate impairment—Walks 6 m (20 ft), slow speed, abnormal gait pattern, evidence for imbalance, deviates 25.4–38.1 cm (10–15 in) outside 30.48-cm (12-in) walkway width.
- (0) Severe impairment—Cannot walk 6 m (20 ft) without assistance, severe gait deviations or imbalance, deviates greater than 38.1 cm (15 in) outside 30.48-cm (12-in) walkway width or will not attempt task.

_____**10. STEPS**

Instructions: _Walk up these stairs as you would at home (ie, using the rail if necessary). At the top turn around and walk down._
Grading: Mark the highest category that applies.
- (3) Normal—Alternating feet, no rail.
- (2) Mild impairment—Alternating feet, must use rail.
- (1) Moderate impairment—Two feet to a stair; must use rail.
- (0) Severe impairment—Cannot do safely.

TOTAL SCORE: _____ MAXIMUM SCORE 30

_____

[a] Adapted from Dynamic Gait Index.[1] Modified and reprinted with permission of authors and Lippincott Williams & Wilkins (http://lww.com).