Testing Functional Performance in People With Parkinson Disease

Background and Purpose. Although the Unified Parkinson's Disease Rating Scale (UPDRS) is the most common performance measure for people with Parkinson disease (PD), the Berg Balance Scale (BBS), Forward Functional Reach Test (FFR), Backward Functional Reach Test (BFR), Timed "Up & Go" Test (TUG), and gait speed may be used to quantify some aspects of functional performance not measured by the UPDRS. The purpose of this study was to describe the relationship among a set of tests of balance, walking performance, and mobility in people with PD. **Subjects.** Twenty-five community-dwelling adults (11 female, 14 male) with a diagnosis of PD were recruited from PD support groups in southeastern Wisconsin and consented to participate in the study. The mean age of the participants was 76 years (SD=7). The average Hoehn and Yahr Stage Scale score was 2. **Methods.** Functional abilities of each subject were assessed with the UPDRS, BBS, FFR, BFR, TUG, and gait speed. Spearman and Pearson correlations were performed. **Results.** The UPDRS total score was correlated with the BBS ($r=-.64$, $P<.001$), FFR ($r=-.52$, $P<.05$), and TUG ($r=.50$, $P<.05$) measurements. The BBS is the only test of functional performance where scores correlate with all other functional tests and the UPDRS. **Discussion and Conclusions.** The UPDRS total score may not reflect a comprehensive measure of mobility in people with PD. Because the BBS scores correlate both with UPDRS scores and with scores of all other tests of functional performance, the BBS appears to be a good overall measure of function in this population. [Brusse KJ, Zimdars S, Zalewski KR, Steffen TM. Testing functional performance in people with Parkinson disease. *Phys Ther.* 2005;85:134–141.]

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Parkinson disease (PD) is a progressive disease associated with a degeneration of the dopamine-producing cells in the substantia nigra.[1] People with PD are known to have a shuffling gait, difficulty initiating movements, a stooped forward posture, marked postural instability, bradykinetic movements, masked facial expression, and tremor.[1] Horak et al[2] described the difficulty people with this disease have in sequencing and executing strategies for postural correction. These movement disorders are the hallmark of PD and can severely compromise an individual's function. Disability eventually occurs with this disease due to the combined effects of many of these impairments.

Physical therapists teach people with PD strategies for coping with impairments and disabilities, ideally allowing clients to move easier, minimize disability, and retain independent living skills. Physical therapists also play a role in assessing the ability of people with PD to accomplish complex tasks, such as shopping, that are routinely performed in everyday life. Therapists are called on to measure and assess changes in function, disability, activity, and response to therapy. In addition, therapists are often called upon to measure and assess changes in the disease, including medication changes and surgical interventions, as well as to monitor the natural progression of the disease.[3–7] Because of the active role physical therapists play in the management of this disease, they need reliable and valid measurements that can comprehensively reflect performance in balance, walking, and mobility tasks in people with PD.

Are Unified Parkinson's Disease Rating Scale (UPDRS) Scores a Valid Indicator of Functional Performance?

The UPDRS was originally developed to serve as an assessment of the severity of the disease.[8–11] The UPDRS consists of 6 sections: I—Mentation (Mental Activity), Behavior, and Mood (4 questions); II—Activities of Daily Living (ADL) (13 questions); III—Motor Examination (14 questions); IV—Complications of Therapy (11 questions); V—the Modified Hoehn and Yahr Stage Scale; and VI—the Schwab and England Activities of Daily Living Scale. Sections I through III are scored on a 5-point Likert scale from 0 to 4, with 0 representing "no impairment" and 4 representing "marked impairment." These 3 sections can be analyzed independently or combined with each other. The UPDRS total score reflects performance on these 3 sections (total possible score of 124), with lower scores showing less disability.[8] Sections of the UPDRS are scored and reported separately.

Section II (ADL) of the UPDRS asks the client to verbally rank his or her perceived ability in many areas, including falling (unrelated to freezing), freezing when walking, and walking. Nine of the 14 items of section III (Motor Examination) of the UPDRS explore motor activity at the impairment level (eg, tremor at rest, action or posture tremor, and leg agility as reflected with heel tapping at a specified amplitude), rather than performance of functional abilities. The 5 items in section III that measure performance of functional abilities are speech, facial expression, rising from a chair, gait, and postural stability; of these items, only the last 3 items are routinely addressed by physical therapists and relate to mobility concerns.

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The UPDRS total score (comprising sections I–III) has good interrater reliability (intraclass correlation coefficient [ICC]=.98, n=40).[9] The UPDRS Motor Examination section yields data with interrater reliability (ICC=.82, n=24).[12] The Cronbach alpha coefficient is .96 for questions 1 through 31 (n=167), indicating internal consistency.[9] The UPDRS total score on sections I through III has been validated by a comparison with data for the Hoehn and Yahr Stage Scale (r_s=.71, P<.001, n=167), the Intermediate Scale for Assessment of Parkinson's Disease (r_s=.92, n=167), and the Schwab and England Activities of Daily Living Scale (r_s=−.76 to .96, P<.001, n=40–127).[9] Although the UPDRS section I through III total score may yield reliable and valid measurements for documenting severity of PD, there is no evidence that the UPDRS adequately measures balance, walking, and mobility performance in people with PD.

There is limited research using the UPDRS total score to show change over time following rehabilitation intervention.[13–15] These authors[13–15] reported improvements in UPDRS scores after rehabilitation; however, only Patti et al[14] measured functional performance with tests other than the UPDRS. Functional Independence Measure scores, Barthel Index scores, and measurements of gait speed were collected, but their relationship to the UPDRS scores was not examined.[14] The concurrent validity of data obtained with the UPDRS and selected tests of functional performance has not been measured in people with PD.

Are Clinical Measurements of Balance, Walking Ability, and Mobility in People With Parkinson Disease Valid?

The Berg Balance Scale (BBS), Forward Functional Reach Test (FFR), Backward Functional Reach Test (BFR), Timed "Up & Go" Test (TUG), and measures of gait speed are tests used to measure function in people with disabilities.[16] We chose them for our study because they are widely reported in the literature and some have been used to examine function in people with PD.[14,17–23] In other adult populations, the BBS, FFR, BFR, TUG, and gait speed have been demonstrated to yield reliable and valid measurements of functional performance.[24,25] In people with PD, concurrent validity between BBS scores and measurements obtained at comfortable gait speeds was explored in one study (r_s=.56, n=40).[17] No other validity research using the BBS has been found. Predictive validity of FFR measurements for falls, using a cutoff of 25.4 cm, had a sensitivity of 30% and a specificity of 92% (n=58).[19] The TUG values have a strong correlation with Hoehn and Yahr Stage Scale scores (r=.75, P<.001, n=33).[22] Comfortable gait speed measurements were correlated with Posturo-Locomotor-Manual Test scores (r_s=.76, n=40).[17] Reporting concur-

rent validity between functional tests and the impairment-heavy content of the UPDRS provides information on which functional tests address the important functional limitations and strengths of people with PD.

The purpose of this study was to describe the relationships between a battery of tests designed to measure balance, walking performance, and mobility in people with PD. Specifically, we (1) examined the concurrent validity between the UPDRS and the several functional tests (ie, BBS, FFR, BFR, TUG, and gait speed) and (2) examined concurrent validity separately between the BBS, FFR, BFR, TUG, and gait speed in people with PD.

Method

Participants
Participants were recruited from 2 community support groups for people with PD and a neurologist's group office whose primary practice specializes in the management of PD. A researcher (TS, LS, or KB) obtained informed consent from each subject. Participants were included in the study if they: (1) were given a primary diagnosis of PD, (2) were able to stand for at least 1 minute without support, and (3) were able to ambulate with or without an assistive device. Twenty-five subjects (14 male, 11 female), between the ages of 61 and 86 years ($\overline{X}$=76, SD=7), met the inclusion criteria and agreed to participate in the study. Two of the participants were unable to complete the entire data collection due to prior time commitments; one of these participants used a wheeled walker and completed only the UPDRS and the BBS. Data from the tests completed were used. Two of the 25 subjects had a history of minor stroke, 5 subjects had a history of heart disease, 1 subject had another neurological disease, and 3 subjects had another medical diagnosis. Seventy-six percent of the subjects tested reported having had previous episodes of dizziness or fainting while walking. None of the secondary diagnoses interfered with their ability to complete the tests and participate in the study. The participants were taking, on average, 2 PD-related medications. Sixty-eight percent of the subjects reported that they felt their medications were at full strength when they began the testing. The average Hoehn and Yahr Stage Scale score was 2 (range=1–4) on the 1 to 5 scale (higher score indicating more impairment). Seventy-one percent of the subjects reported having slight or no resting tremor. The mean UPDRS score for participants in the study was 28 (SD=15). Table 1 gives the means, standard deviations, and confidence intervals for participants' data on the UPDRS and functional tests.

Procedure
Three examiners participated in data collection. Rater 1 (KC) administered all testing, and raters 2 (KB) and

Table 1.
Means, Standard Deviations, 95% Confidence Intervals (95% CIs), and Intraclass Correlation Coefficients (ICCs) for Reproductivity (N=23–24) for Measures of Functional Performance in People With Parkinson Disease

Test Performed	X̄	SD	95% CI	Reproducibility (ICC [3,1])
Unified Parkinson's Disease Rating Scale				
Mentation, Behavior, and Mood (range=0–16)	3	3	2–4	
Activities of Daily Living (range=0–52)	11	6	9–14	
Motor Examination (range=0–56)	14	7	11–17	
Total score (range=0–124)	28	15	22–35	
Berg Balance Scale (range=0–56)	46	7	43–49	
Forward Functional Reach Test (cm)	18.4	7.2	15.3–21.5	.86 (3 trials)
Backward Functional Reach Test (cm)	13.5	7.9	10.1–16.8	.87 (3 trials)
Timed "Up & Go" Test (s)	14.8	5.8	12.3–17.3	.94 (2 trials)
Comfortable gait speed (m/s)	0.91	0.21	0.82–1.01	.90 (2 trials)
Fast gait speed (m/s)	1.24	0.33	1.10–1.38	.94 (2 trials)

rater 3 (SZ) independently recorded performance results on all functional tests. Testing began when rater 1 administered the UPDRS after the consent and demographic data were collected. After the UPDRS was completed, the BBS, FFR, BFR, TUG, and gait speed data were collected. The order of testing was the same for all participants. The total time to administer the test battery was approximately 30 minutes per participant. Rest time was allotted as needed between tests or portions of a test. Participants were mailed a copy of their results at the completion of the study.

Studies have demonstrated the test-retest reliability of FFR,[18,26] TUG,[21] and gait speed[23] data in people with PD. The reliability of data obtained with the BBS and BFR in people with PD is not known. For this study, interrater reliability was established for raters 2 and 3 (ICC [2,1]=.98 or above) using functional test scores from the first 8 participants enrolled in the study. Because of the high interrater reliability obtained for raters 2 and 3, an average of the trials of rater 2 on the initial 8 participants and data obtained for all subsequent participants were the only scores used in the data analysis. The UPDRS motor examination section (14 items) in this study had an internal consistency value of .89, and the UPDRS total score (31 items) had an internal consistency value of .94.

The reproducibility of same-day measurements was determined for the FFR, BFR, TUG, and gait speed measures using ICC [2,1] for the 23 subjects who were able to complete all tests.[27] In order to mimic clinical practice and to calculate same-day reproducibility, we asked participants to complete 2 additional trials after their first trial of a functional task. The reproducibility of the tests on the same day ranged from .86 to .94 (Tab. 1). These statistics might help the clinician decide if an

average of multiple trials is required or if a single trial will suffice when obtaining data for the FFR, BFR, TUG, and gait speed in people with PD. The measurements had excellent same-day reproducibility.

Functional Testing Protocols
Twenty-four participants completed the UPDRS, and 23 participants completed the remaining functional testing. The one participant who required an assistive device was not able to complete all tests due to scheduling conflicts.

BBS. The participants completed 13 of 14 activities related to balance in the BBS. Item 8 of the BBS (reaching forward with the outstretched arm) was completed as part of the FFR, which followed the BBS. The average distance reached was converted from centimeters to inches and included in the final scoring of the BBS. Equipment used included: a stopwatch, a firm chair with arms (seat height of 46 cm), a step stool 23 cm from the floor, and a slipper (1-in height). The same equipment was used for each subject, and all instructions were administered as outlined in the BBS directions.[28] Internal consistency of the 14 items on the BBS was .88.

FFR and BFR. To obtain precise measurements, a sliding wooden bevel was attached to a leveling device that contained marked increments (in centimeters). The level was fastened to an adjustable tripod that allowed measurements to be taken at the height of each subject's acromion. For the FFR, the subject was instructed, "On your dominant side, raise your arm out in front to shoulder height and form a fist. Reach forward as far as possible without moving your feet and without losing your balance. Keep your arm at the height of the level as you reach forward." A loss of balance was identified as raising the heels off the ground or taking a step in any direction. Four trials were performed: 1 practice trial

Table 2.
Spearman Correlations of Unified Parkinson's Disease Rating Scale (UPDRS) and Berg Balance Scale With Functional Performance Tests in People With Parkinson Disease (N=23)

	UPDRS Mentation, Behavior, and Mood (Section I)	UPDRS Activities of Daily Living (Section II)	UPDRS Motor Examination (Section III)	UPDRS Total Score
Berg Balance Scale	−.48[a]	−.54[b]	−.69[c]	−.64[c]
Forward Functional Reach Test	−.46[a]	−.51[a]	−.45[a]	−.52[a]
Backward Functional Reach Test	−.33[d]	−.35[d]	−.33[d]	−.39[d]
Timed "Up & Go" Test	.34[d]	.37[d]	.58[b]	.50[a]
Comfortable gait speed	−.12[d]	−.20[d]	−.36[d]	−.27[d]
Fast gait speed	−.18[d]	−.27[d]	−.32[d]	−.31[d]

[a] $P<.05$.
[b] $P<.01$.
[c] $P<.001$.
[d] NS=not significant.

and 3 measured trials. The beginning measurement was subtracted from the final measurement to determine the distance of the reach. An average of 3 trials was used in the data analysis, similar to the procedure used by the original researchers.[29] The same measurement device and protocol used for the FFR were used for the BFR. For the BFR, the subject was instructed, "On your dominant side, raise your arm out in front to shoulder height and form a fist. Lean back as far as possible without moving your feet or losing your balance. Keep your arm at the height of the level as you lean back." The rest of the measurements and analysis for the BFR were the same as for the FFR.

TUG. A distance marker made with tape and marked by a cone was placed on the floor 3 m from the front of a chair. The chair had a seat height of 46 cm. Each subject was instructed to sit in the chair with his or her back and hips against the chair and arms resting on the armrests. Directions were "When I say go, walk at a safe pace, go around the cone, and come back and sit in the chair." Timing began on "go" and stopped when the subject's back was against the chair. The subject had 1 practice trial and 2 timed trials for this test. Time was measured in seconds. The 2 timed trials were averaged for data analysis.[24,30]

Gait speed. A distance of 10 m was marked on the floor with colored tape. Subsequent marks were placed 2 m from the starting point and 2 m from the ending point to allow a 6-m timed middle section for the test. Timing began when the subject crossed the initial 2-m mark and ended when the subject crossed the final 2-m mark. Each subject was given 4 trials, 2 at a comfortable walking speed and 2 at a fast walking speed. The instructions for comfortable walking speed were, "Walk all the way to the last piece of tape at your comfortable walking speed; you can start when I say 'go.'" For fast walking speed, the

instructions were, "Walk all the way to the last piece of tape as fast as you can safely walk; you can start when I say 'go.'" Repetition of the directions and demonstration of the task were provided as needed. Time was measured in seconds and converted to meters per second. Two trials at each speed were averaged.[24,31]

Data Analysis
Statistical analyses were performed using the SPSS/PC (Version 10.0) software program.* To explore concurrent validity between the UPDRS scores and data obtained for the other tests of functional performance, the UPDRS total score and section scores were correlated with the BBS, FFR, BFR, TUG, and gait speed data using the Spearman rho (r_s) statistic. To examine concurrent validity separately between the BBS, FFR, BFR, TUG, and gait speed, Pearson correlations were used. The required level of significance for all tests was set at $P<.05$. The criteria used to evaluate correlation coefficients were: fair (values of .25–.50), moderate to good (values of .50–.75), and excellent (values of .75 and above).[27]

Results
Table 1 presents the means, standard deviations, 95% confidence intervals (CIs), and ICCs for reproducibility of same-day measurements of all functional tests used in the study. Data describing the relationship between the UPDRS and tests of functional performance and the relationships of the clinical functional performance measures to each other are shown in Tables 2 and 3. Table 2 outlines the Spearman correlations of the UPDRS scores with the data for the BBS, FFR, BFR, TUG, and comfortable and fast gait speeds. The UPDRS Mentation, Behavior, and Mood section and ADL sec-

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Table 3.
Correlations of Functional Assessment Tests (N=23) in People With Parkinson Disease

	Forward Functional Reach Test (FFR)	Backward Functional Reach Test (BFR)	Timed "Up & Go" Test (TUG)	Comfortable Gait Speed (CGS)	Fast Gait Speed (FGS)	Berg Balance Scale (BBS)
BFR[a]	.37					
TUG[a]	−.20	−.35				
CGS[a]	.21	.63[d]	−.67[d]			
FGS[a]	.13	.43[c]	−.69[d]	.89[d]		
BBS[b]	.50[c]	.51[c]	−.78[d]	.73[d]	.64[d]	

[a] Pearson correlations.
[b] Spearman correlations.
[c] $P<.05$.
[d] $P<.001$.

tion scores were correlated with the BBS and FFR data but not with the data for the BFR, TUG, and comfortable and fast gait speeds. The UPDRS Motor Examination section scores and the UPDRS total score were correlated with the BBS, FFR, and TUG data but not with either BFR or gait speed data.

Table 3 reports Pearson correlations between the 5 functional tests. The BBS scores had good to excellent correlations with the TUG and gait speed measurements and fair to good correlations with the FFR and BFR measurements. The FFR data were not correlated with the data for any of the other measures. The BFR data were correlated with measurements of gait speed. The TUG data were moderately correlated with measurements of gait speed.

Discussion

The BBS scores were correlated with the scores on the Motor Examination section of the UPDRS ($r=-.69$, $P<.001$), indicating overlap of their constructs, most likely related to upright postural control. The BBS and items 28 to 30 of the UPDRS Motor Examination section both measure postural stability (Tab. 2). The UPDRS likely measures some aspect of mobility as well, as evidenced by the correlation between the scores on the Motor Examination section of the UPDRS (containing both rising from a chair and gait) and the TUG measurements ($r=.58$, $P<.01$). However, the UPDRS scores did not correlate with the measurements of comfortable and fast gait speed, suggesting that the UPDRS does not reflect walking performance when it is used to measure disease severity. Because the UPDRS has only one item (item 29) in which the examiner observes bradykinesia while subjects are walking, it is likely that the full impact of disease severity on walking function is not well represented. Clinicians should recognize that the UPDRS does not measure walking performance as measured by gait speeds and that walking performance may have to be measured separately.

Of all of the functional tests examined, the BBS is more strongly correlated with a greater number of measures used in this study, indicating its comprehensive relationship to balance, mobility, and walking speed in this population. Based on the clinical tests used in this study, if a physical therapist had to choose a single comprehensive clinical functional performance measure for people with early and middle stages of PD, we would recommend starting with the BBS. The BBS has been used to predict the likelihood of falls in community-dwelling elderly people. Using a cutoff of 50, the BBS has been shown to have sensitivity (85%) and specificity (73%) for people who are at risk for falling.[32] Our study had a mean BBS score of 46, with a confidence interval of 43 to 49. Using this criterion, we could hypothesize that some of the sample would be at risk for falls over the course of the next 12 months. However, a study on sensitivity and specificity as they relate to falling, test-retest reliability, and responsiveness to change in people with PD is still needed.

The average FFR value of 18.4 cm in our study is below the published cutoff of 24.5 cm for community-dwelling elderly men who fall.[33] Our FFR data were moderately correlated with the BBS data but not with the BFR, TUG, or comfortable and fast gait speed data. People with PD have kyphosis or posture associated with hip flexor tightness (stooped with flexion at the hips) while in an upright position.[1] The measure of their forward limits of stability does not predict falling.[34] The BFR requires people with PD to voluntarily reach their limits of stability in the posterior direction without falling. Interestingly, our BFR data were correlated with measurements recorded at comfortable gait speeds ($r=.63$, $P<.001$) and with measurements recorded at fast gait speeds ($r=.43$, $P<.05$) (Tab. 3). Although our study was cross-sectional, we may speculate that increases in backward limits of stability could relate to improvement in walking speed, perhaps related to an improved upright posture or improved force coordination between hip

flexors and extensors. The different relationship of forward and backward limits of stability to gait speed suggests that the BFR may measure unique performance data in people with PD and warrants further study.

The average TUG measurement for our subjects with PD was higher (representing slower movement) than the average TUG values reported for community-dwelling elderly people.[24,30] The TUG data were correlated with the data for all measures except the functional reaches. The TUG is reported in the literature as a mobility measure.[35] The TUG data were correlated with the BBS scores ($r_s = -.78$) and with the measurements of comfortable and fast gait speed ($r = -.67$ and $r = -.69$, respectively). These correlations demonstrate that mobility, ambulation, and balance are not mutually exclusive constructs.

Mean gait speeds in our study were slower than those reported for community-dwelling elderly people.[24,36] This finding is consistent with bradykinetic movements associated with PD. If the UPDRS is utilized in the clinic and research, then gait speed should be added to fully document ability in this meaningful activity. Comfortable and fast gait speeds were correlated with the BBS scores ($r_s = .73$ and $.64$). Because of this correlation, if the BBS is used for the assessment, the physical therapist may be less concerned with measuring gait speed.

Future studies are needed to explore other types of validity in the use of the BBS, BFR, FFR, TUG, and measures of gait speed in people with PD. Most interesting to clinicians will be the ability of these tests to measure responsiveness to change with intervention.[37,38] Further study also may be warranted to examine the relationship between posterior limits of stability with the BFR and measures of gait speed.

Limitations
The limitations of this study include the small number of participants, which affected the range of disability that accompanies PD. Although correlational studies do not give insight into the causal nature of altered physical function, they can demonstrate reliability and validity of data obtained for people with PD. Physical therapists also require their tools to yield data with predictive validity or sensitivity/specificity (eg, for risk of falling) as well as to have responsiveness to change. This study did not examine these characteristics of the tests.

Conclusion
Our results indicate that the UPDRS does not measure constructs reflected by comfortable or fast gait speed or backward limits of stability in adults with PD. The BBS scores were strongly correlated with the data obtained for comfortable and fast gait speeds, the TUG, and backward limits of stability. The addition of the BBS to traditional physical therapist examination of people with PD may provide physical therapists and researchers with a more comprehensive representation of balance, walking, and mobility performance than the UPDRS alone.

References

1 Meara J, Bhowmick BK. Parkinson's disease and parkinsonism in the elderly: introduction. In: Meara J, Koller WC, eds. *Parkinson's Disease and Parkinsonism in the Elderly.* Cambridge, United Kingdom: Cambridge University Press; 2000:22–53.

2 Horak F, Nutt J, Nashner L. Postural inflexibility in Parkinsonian subjects. *J Neurol Sci.* 1992;111:46–58.

3 Morris ME. Movement disorders in people with Parkinson's disease: a model for physical therapy. *Phys Ther.* 2000;80:578–597.

4 Schenkman M, Donovan J, Tsubota J, et al. Management of individuals with Parkinson's disease: rationale and case studies. *Phys Ther.* 1989;69:944–955.

5 Canning CG, Alison JA, Allen NE, Groeller H. Parkinson's disease: an investigation of exercise capacity, respiratory function, and gait. *Arch Phys Med Rehabil.* 1997;78:199–207.

6 Morris ME, Iansek R, Churchyard A. The role of the physiotherapist in quantifying movement fluctuations in Parkinson's disease. *Aust J Physiother.* 1998;44:105–114.

7 Schenkman M, Butler RB. A model for multisystem evaluation and treatment of individuals with Parkinson's disease. *Phys Ther.* 1989;69:932–943.

8 Fahn S, Elton RL, Members of the UPDRS Development Committee. Unified Parkinson's Disease Rating Scale. In: Fahn S, Marsden CD, Calne D, et al, eds. *Recent Developments in Parkinson's Disease.* Florham Park, NJ: Macmillan Healthcare Information; 1987:153–164, 293–304.

9 Martinez-Martin P, Gil-Nagel A, Gracia LM, et al. Unified Parkinson's Disease Rating Scale characteristics and structure. *Mov Disord.* 1994;9:76–83.

10 Baas H, Stecker K, Fischer PA. Value and appropriate use of rating scales and apparative measurements in quantification of disability in Parkinson's disease. *J Neural Transm Park Dis Dement Sect.* 1993;5:45–61.

11 Goetz CG, Stebbins GT, Shale HM, et al. Utility of an objective dyskinesia rating scale for Parkinson's disease: interrater and intrarater reliability assessment. *Mov Disord.* 1994;9:390–394.

12 Richards M, Marder K, Cote L, Mayeux R. Interrater reliability of the Unified Parkinson's Disease Rating Scale motor examination. *Mov Disord.* 1994;9:89–91.

13 Comella CL, Stebbins GT, Brown-Toms N, Goetz CG. Physical therapy and Parkinson's disease: a controlled clinical trial. *Neurology.* 1994;44:376–378.

14 Patti F, Reggio A, Nicoletti F, et al. Effects of rehabilitation therapy on Parkinson's disability and functional independence. *J Neurol Rehabil.* 1996;10:223–231.

15 Reuter I, Engelhardt M, Stecker K, Baas H. Therapeutic value of exercise training in Parkinson's disease. *Med Sci Sports Exerc.* 1999;31:1544–1549.

16 Arnadottir S. Functional assessment in geriatric physical therapy. *Issues on Ageing.* 1999;22(2):3–12.

17 Kokko SM, Paltamaa J, Ahola E, Malkia E. The assessment of functional ability in patients with Parkinson's disease: the PLM-test and three clinical tests. *Physiother Res Intl.* 1997;2(2):29–45.

18 Smithson F, Morris M, Iansek R. Performance on clinical tests of balance in Parkinson's disease. *Phys Ther.* 1998;78:577–592.

19 Behrman A, Light K, Flynn S, Thigpen M. Is the functional reach test useful for identifying falls risk among individuals with Parkinson's disease? *Arch Phys Med Rehabil.* 2002;83:538–542.

20 Grill S. Postural instability in Parkinson's disease. *Md Med J.* 1999;48:179–181.

21 Morris S, Morris ME, Iansek R. Reliability of measurements obtained with the Timed "Up & Go" Test in people with Parkinson's disease. *Phys Ther.* 2001;81:810–818.

22 Thompson M, Medley A. Performance of individuals with Parkinson's disease on the Timed Up & Go. *Neurology Report.* 1998;22:16–21.

23 Morris ME, McGinley J, Huxham F, et al. Constraints on the kinetic, kinematic, and spatial temporal parameters of gait in Parkinson's disease. *Hum Mov Sci.* 1999;18:461–483.

24 Steffen T, Hacker T, Mollinger L. Age-and gender-related test performance in community-dwelling elderly people: Six-Minute Walk Test, Berg Balance Scale, Timed Up & Go Test, and gait speeds. *Phys Ther.* 2002;82:128–137.

25 Lusardi M, Pellechia G, Schulman M. Functional performance in community living older adults. *Journal of Geriatric Physical Therapy.* 2003;26(3):14–22.

26 Schenkman M, Cutson TM, Kuchibhatla M, et al. Reliability of impairment and physical performance measures for person's with Parkinson's disease. *Phys Ther.* 1997;77:19–26.

27 Portney L, Watkins M. *Foundations of Clinical Research: Applications to Practice.* 2nd ed. Englewood Cliffs, NJ: Prentice-Hall Inc; 2000.

28 Berg K. The berg balance scale. *Geri Notes.* 1998;5(4):12–14.

29 Duncan P, Weiner D, Chandler J, Studenski S. Functional Reach: a new clinical measure of balance. *J Gerontol Med Sci.* 1990;45:M192–M197.

30 Rockwood K, Awalt E, Carver D, MacKnight C. Feasibility and measurement properties of the functional reach and the timed up and go tests in the Canadian Study of Health and Aging. *J Gerontol A Biol Sci Med Sci.* 2000;55:M70–M73.

31 Bohannon RW. Comfortable and maximum walking speed of adults aged 20–79 years: reference values and determinants. *Age Ageing.* 1997;26:15–19.

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

33 Duncan P, Goldstein L, Matchar D, et al. Measurement of motor recovery after stroke. *Stroke.* 1992;23:1084–1089.

34 Behrman AL, Teitelbaum P, Cauraugh JH. Verbal instructional sets to normalise the temporal and spatial gait variables in Parkinson's disease. *J Neurol Neurosurg Psychiatry.* 1998;65:580–582.

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

36 Brach J, VanSwearingen J, Newman A, Kriska A. Identifying early decline of physical function in community-dwelling older women: performance-based and self-report measures. *Phys Ther.* 2002;82:320–328.

37 Salbach N, Mayo N, Higgins J, et al. Responsiveness and predictability of gait speed and other disability measures in acute stroke. *Arch Phys Med Rehabil.* 2001;82:1204–1212.

38 Miyai I, Fujimoto Y, Yamamoto H, et al. Long-term effect of body weight-supported treadmill training in Parkinson's disease: a randomized controlled trial. *Arch Phys Med Rehabil.* 2002;83:1370–1373.