Five Times Sit to Stand Test Performance in Parkinson Disease

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Abstract

Objectives—Our objectives were to: 1) determine intra-rater and test-retest reliability of the FTSTS in Parkinson disease (PD), 2) characterize Five Time Sit to Stand (FTSTS) performance in PD at different disease stages, 3) determine predictors of FTSTS performance in PD, and 4) determine utility of the FTSTS for discriminating between fallers and non-fallers with PD, identifying an appropriate cutoff score to delineate between these groups.

Design—Measurement study of community-dwelling individuals with idiopathic PD.

Setting—Participants were examined in a medical school laboratory.

Participants—Eighty-two participants were recruited via population-based sampling. The final sample included eighty participants. Two were excluded per exclusion criteria and unrelated illness, respectively.

Interventions—Not applicable.

Main Outcome Measure(s)—Five Times Sit to Stand Test (FTSTS) time (seconds). Secondary outcome measures included: Mini-Balance Evaluation Systems Test (Mini-BEST), Maximal Voluntary Isometric Contraction – Quadriceps (MVIC), nine hole peg test (9HPT), six minute walk, freezing of gait questionnaire, Activities-specific Balance Confidence Scale, Physical Activity Scale for the Elderly, Parkinson Disease Questionnaire-39, and Movement Disorders Society-Unified Parkinson Disease Rating Scale.

Results—Interrater and test-retest reliability for the FTSTS were high (Intraclass correlation coefficients of 0.99 and 0.76, respectively). Mean FTSTS performance was 20.25 ± 14.12 (seconds). All mobility measures were significantly correlated with FTSTS (p<0.01). The Mini-BEST and 9HPT together explained 53% of the variance in FTSTS. Receiver Operating Characteristic (ROC) analysis determined a cutoff of 16.0 seconds (sensitivity = 0.75, specificity = 0.68) for discriminating between fallers and non-fallers, with an area under the curve (AUC) of 0.77.

Conclusion—The FTSTS is a quick, easily administered measure useful for gross determination of fall risk in individuals with PD.

Keywords

Parkinson disease; falls; sit to stand

Introduction

PD is a progressive neurodegenerative disorder affecting between 1–2% of individuals over 65 years of age and 3–5% of those 85 or older [1]. Characterized by a loss of dopaminergic neurons in the substantia nigra, PD leads to cardinal symptoms of tremor, bradykinesia, rigidity, and postural instability [1]. Weakness has also been proposed as a primary symptom in PD [2]. Lower extremity strength [3], postural instability [4] and freezing of gait [5,6] appear to play major roles in falls which occur in 40%–70% of individuals with PD [7]. Due to the high number of falls and subsequent injuries, establishment of an outcome measure that reflects both lower extremity strength and balance deficiencies in individuals with PD may prove useful.

Repeated performance of sit-to-stand has often been utilized as a measure of lower extremity strength [8,9]. People with PD are known to produce smaller lower extremity forces than controls, especially at the hip, which may contribute to the ability to ascend from a chair [10]. Other studies demonstrated that sit-to-stand performance is also influenced by balance [11,12]. When measured in individuals with and without balance disorders, the positive predictive value of the FTSTS was 61% [13]. The FTSTS has also been shown to have added value in estimating the possibility of recurrent falls in community-dwelling individuals at moderate risk for falls, as those individuals in the "moderate risk" group with an FTSTS score of >15 seconds were found to have twice as many falls as those individuals who performed the FTSTS in less than 15 seconds [14]. Finally, the FTSTS has high test-retest reliability when examined in healthy, older individuals (ICC = 0.89–0.96) [11] as well as those with chronic stroke (ICC range = 0.989–0.999) [15]. While the FTSTS would appear to be very useful for assessing fall risk in individuals with PD, as strength and balance deficiencies are prominent, it has not yet been examined in this population.

In examining individuals with PD, the objectives of this study were to: 1) determine intra-rater and test-retest reliability of the FTSTS in PD, 2) characterize FTSTS performance times in PD at different disease stages, 3) determine the predictors of FTSTS performance in people with PD, and 4) determine the utility of the FTSTS for discriminating between individuals with PD with and without a history of falls and identify an appropriate cutoff score to delineate between these groups.

We hypothesized that: 1) the FTSTS would demonstrate acceptable intra-rater and test-retest reliability when used for people with PD, 2) individuals with more severe PD would perform the FTSTS more slowly than individuals with less severe PD, 3) common features of PD (postural instability, bradykinesia, freezing of gait, weakness, etc.) would be predictive of FTSTS performance, and 4) the FTSTS test would discriminate well between fallers and non-fallers.

Methods

Participants

Participants were recruited using databases from the Washington University School of Medicine's (WUSM) Movement Disorders Center and the WUSM Volunteers for Health. The population targeted was individuals with a diagnosis of idiopathic PD (H&Y Stages I–IV) who were over the age of forty, community-dwelling and able to give informed consent.

Via telephone interview and database records, potential participants were excluded based on the following criteria: 1) atypical parkinsonism, or 2) previous surgical management of PD (e.g. deep brain stimulation).

Outcome Measures

FTSTS Test—Participants began this test sitting in an armless chair that was 43 centimeters from the ground [16]. Each participant was instructed to cross his arms over his chest and sit with his back against the upright back rest of the chair. The rater then demonstrated the correct technique for performance of the test, including coming to a full stand, defined as an upright trunk with the hips and knees extended. Timing began when the rater spoke the word "go" and stopped when the participant's buttocks reached the seat following the fifth stand.

Hoehn & Yahr Stage of Disease Severity (H&Y)—The H&Y stage [17,18] was used for assessing disease severity in individuals with PD. Stages range from zero (asymptomatic) to five (wheelchair bound/bedridden). To assign an H&Y stage, laterality of symptoms and postural instability are assessed.

Mini-Balance Evaluation Systems Test (Mini-BEST)—The Mini-BEST [19] is a newly developed 14-item balance test that has high inter-rater reliability (ICC ≥ 0.92) and high test-retest reliability (ICC ≥ 0.88) when testing individuals with PD [20]. The instrument examines several postural control systems through performance of dynamic balance tasks. As poor balance is a common manifestation of PD, this test was utilized to determine how balance may affect sit to stand performance.

MVIC -Quadriceps—A MicroFET2 [Hoggan Health Industries, West Jordan, UT] dynamometer was used to measure the maximal voluntary isometric contraction of the quadriceps muscles. Each participant was seated on a table with his back against a wall in a position in which the lower leg was parallel with the support leg of the table. The dynamometer was fixed in place on the tibia five centimeters above the lateral malleolus using a gait belt that was secured around the support leg of the table. Knee and hip flexion were set at ninety degrees and knee angle was confirmed using a goniometer. The participant was then instructed to push out as hard as possible for five seconds as if trying to straighten their knee. A practice trial was given to familiarize the participant with the device and the evaluation process. Following each trial, the peak force value (kg) was recorded and the participant was given a one minute rest period before the next trial. Three trials were recorded for each lower extremity. Quadriceps strength was given a composite value by dividing the mean bilateral strength score (mean bilateral strength score = average of left trials + average of right trials, divided by two) by body weight in kilograms [12,21,22].

Six Minute Walk Test (6MWT)—Distance covered in the 6MWT was utilized as a measure of endurance. This test has high test-retest reliability (ICC = 0.96) in PD [23]. Rationale for employing this test was derived from a previous study showing that mobility impairments (Berg Balance Scale, Timed Up and Go, Freezing of Gait Questionnaire) were related to 6MWT distance in individuals with PD [24]. Therefore, the 6MWT may be related to FTSTS performance. Participants were instructed to walk at a safe, comfortable pace while trying to cover as much ground as possible. A 30.48 meter hallway served as the venue for the 6MWT. Distance covered in six minutes was measured to the nearest meter.

Nine Hole Peg Test (9HPT)—The 9HPT is used in clinical settings to examine upper extremity function. In this study, the 9HPT was used to measure bradykinesia, as a former study demonstrated that bradykinesia was able to explain a significant portion in the

variance in 9HPT performance [25]. This would allow determination of whether or not bradykinesia is related to FTSTS performance. Using only one hand, participants were asked to place nine pegs, one at a time, in nine holes as quickly as possible. Once the nine holes were filled, without stopping time, the participant was instructed to remove the pegs individually and set them in the tray. Time was stopped when the last peg was hit the tray. Participants performed two trials with each hand, beginning with the dominant hand. The participant was allowed to use the opposite hand to stabilize the peg board. Scoring for this test was completed by taking the average time of the four trials.

Fall History—Retrospective history of falls was collected from each participant. To determine whether a participant was a faller or non-faller, they were asked how often they fell in the past six months. Response options were: once, 2–10 times, weekly, or daily. If the participant chose one of the final three options, they were considered to be a faller.

Questionnaires—The Freezing of Gait Questionnaire (FOGQ) is a highly reliable (r=0.84) and valid tool that can identify 85.9% of individuals who experience freezing [26]. It includes six questions, which assess walking performance in the participant's worst state, how gait difficulties affect independence, whether or not one experiences freezing, and characteristics of the freezing episodes. The FOGQ was employed in this study to understand how freezing might relate to FTSTS performance. Balance confidence was assessed using the Activities-specific Balance Confidence Scale (ABC) scale [27], which has high test-retest reliability (ICC = 0.94) in PD [23]. The Physical Activity Scale for the Elderly (PASE)[28], which is reliable and valid, is aimed at assessing activity engagement in older individuals in just the past week [29]. Quality of life was measured using the PD Questionnaire – 39 (PDQ-39), which consists of eight subsections (PDQ-Mobility, PDQ-Stigma, etc.). All of the subsections scored together bring about a total referred to as the Summary Index (PDQ-SI). The PDQ-39 has good internal, construct, and test-retest reliability [30,31]. The summary index and mobility scores were used for this study.

Procedures

All participants gave written informed consent in accordance with the policies and procedures of the Washington University Human Research Protection Office. Demographic information, height, and weight for each participant were obtained and questionnaires, including fall history, were completed. The order of administration for outcome measures was: Mini-BEST, FTSTS, quadriceps dynamometry, 9HPT, and 6MWT. A specially trained physical therapist administered all measures while participants were in the 'on' phase of their medication. In order to test inter-rater and test-retest reliability, a smaller sub-sample (n=10) of individuals with PD was tested. Two raters simultaneously timed two trials of the FTSTS for each participant. For test-retest reliability, the same procedure was carried out with seven days between testing periods.

Data Analysis

Intraclass correlation coefficients (ICC) were used to determine inter-rater (ICC 1,1) and test-retest (ICC 2,1) reliability of the FTSTS. A two-sample t-test was used to compare FTSTS performance in males as compared to females. To determine relationships between FTSTS performance and all other measures, Pearson correlations were utilized. Quantitative measures specific to mobility that were most related to FTSTS performance (i.e. correlations with p values < 0.01) were entered into a stepwise multiple regression analysis to establish factors most predictive of FTSTS performance. Also, a cutoff score regarding FTSTS performance in fallers vs. non-fallers was determined using an ROC curve, with the cutoff chosen at the minimum value of: $(1-\text{sensitivity})^2 + (1-\text{specificity})^2$. Data analysis was completed using NCSS software version 7.1.19 [32].

Results

Eighty-two individuals with PD agreed to participate in the study; however, two were eliminated due to exclusion criteria and an unrelated illness, respectively. The final sample included eighty participants (59% men; mean age, 67 ± 9.0, mean H&Y, 2.4 ± 0.6). Individuals in each H&Y stage (I=2, II=2, III=2, and IV=1) were unable to perform the FTSTS as they were unable to arise from a chair without using the upper extremities. As such, these participants were given a score of sixty seconds which was approximately one standard deviation higher than the slowest performance time among those who were able to perform the task.

Reliability of FTSTS in PD

ICCs for inter-rater reliability were 0.99. Test-retest reliability with one week between testing periods had an ICC of 0.76.

FTSTS Performance in PD

The time taken to complete the FTSTS, without regard for disease severity, was 20.25 ± 14.12 (mean $\pm$ SD) in individuals with PD. Table 1 displays FTSTS performance as it relates to disease severity. There were no significant differences in FTSTS times for the different H&Y stages nor between men and women. Pearson correlation coefficients reveal the relationships between FTSTS performance and demographics, self-report measures, and mobility measures. All mobility measures were significantly correlated with FTSTS performance (Table 2), most notably Mini-BEST ($r =-0.71$, p<.001), 6MWT ($r = -0.60$, p <.001), and 9HPT ($r = 0.55$, p <.001). All questionnaire scores as well as age were also significantly correlated to FTSTS performance (Table 2).

Predictors of FTSTS Performance in PD

A multiple regression analysis revealed that the Mini-BEST and 9HPT combined explained 53% of the variance in FTSTS performance (Table 3 – Model 1). A second regression model with all measures included was similar, predicting only 55% of the variance in FTSTS performance (Table 3 – Model 2). Cumulative R^2 refers to total overall R^2 when all variables up to and including the variable in question have been entered into the model.

Discriminative Ability of FTSTS

Figure 1 presents the ROC curve for discriminating between fallers and non-fallers utilizing the FTSTS. The cutoff score was 16.0 seconds [AUC = 0.77, sensitivity = 0.75, specificity = 0.68].

Discussion

Reliability of FTSTS in PD

To the authors' knowledge, this is the first study to examine inter-rater and test-retest reliability of the FTSTS in PD. The results of this study demonstrate excellent inter-rater reliability of the FTSTS comparable to that reported in chronic stroke (ICC =0.99)[15]. Test-retest reliability of the FTSTS in PD is also comparable to that of other populations (ICC range 0.64–0.96)[11,33–36].

FTSTS Performance in PD

We sought to examine FTSTS performance as it relates to the H&Y stages of disease severity in PD. In contrast to expectations, there were no differences in FTSTS performance in relation to disease severity, and with respect to individuals (grouped by H&Y stage)

unable to complete the test successfully between groups, the number was almost equal. This could be due to specific criteria within the H&Y staging that refer only to the laterality of symptoms and the individual's ability to stand, ambulate and respond to a postural perturbation without respect for the actual sit-to-stand movement [17]. It is also possible that over time, individuals with PD utilize compensatory strategies in the sit-to-stand movement, which could reduce the expected decline in FTSTS performance as the disease progresses [37].

Measures moderately and significantly correlated with FTSTS performance included age, balance, walking endurance, and bradykinesia (as assessed by the 9HPT). Other studies of healthy older individuals and individuals with stroke have found only weak correlations of age with sit-to-stand performance, but have noted stronger correlations similar to those reported here between balance and sit-to-stand performance [11,12]. Our results suggest that sit-to-stand performance is also correlated with balance confidence (ABC) and mobility-related quality of life (PDQ-Mobility) in PD, with those who take longer to perform the FTSTS having lower balance confidence and poorer quality of life. Those with slower 9HPT performance also had slower FTSTS performance. Overall quality of life (PDQ-SI) and physical activity level (PASE) appear less related to ability to rise from a chair in individuals with PD.

Predictors of FTSTS Performance in PD

Lower extremity strength was initially thought to be the fundamental construct influencing results on the FTSTS test; however in people with PD, balance and bradykinesia seem to be the most important contributing factors per the results of our regression analysis. Overall, the Mini-BEST balance test and 9HPT explained 53% of the variance in FTSTS performance in individuals with PD. Balance has been implicated as a contributing factor in FTSTS performance in other studies [11,12]; however this is the first study to examine a measure of bradykinesia and link it to a timed sit-to-stand test. All other variables, including lower extremity strength, entered into the regression analysis explained only an additional 2% of the variance in sit-to-stand performance. As such, lower extremity strength appears to not be as strongly related to FTSTS performance in PD as it is in other populations.

FTSTS Performance Comparison Between Populations

This is the first study to examine FTSTS performance in individuals with PD. In reviewing previous literature looking at FTSTS performance in other populations, mean performance times (in seconds) are as follows: PD (20.25±14.12), healthy elderly (13.40±2.80)[13], elderly with balance problems (16.40±4.40) [13], and chronic stroke (17.90±9.60) [12]. It is not surprising that the three populations known to have balance problems performed more slowly than the healthy older adults as balance is known to influence sit-to-stand performance [11,12]. It seems that bradykinesia, a symptom unique to PD, may be an underlying factor in the differences between PD, elderly with balance problems, and those with chronic stroke, as bradykinesia was found to be a contributing factor to FTSTS performance in individuals with PD. Regarding healthy older adults, lower extremity strength has been shown to be a strong predictor in sit-to-stand performance [38,11], while the contribution of lower extremity strength to the percentage of explained variance in PD is negligible. This suggests that strength may be a factor that sets apart older individuals with balance problems from individuals with PD when examining FTSTS performance.

Utility of FTSTS as a Fall Risk Assessment in PD

Difficulty rising from a chair has been associated with fall risk for healthy older individuals [39,40]. The ability of the FTSTS to predict the risk of falls in older adults has been previously examined [41]; one objective of the present study was to determine the ability of

the FTSTS to distinguish between those who fall and those who do not fall among individuals with PD. The AUC for the FTSTS was 0.77 with a cutoff score of 16 seconds (sensitivity = 0.75, specificity = 0.68). In a study examining older adults, the optimal cutoff score for predicting recurrent fallers was 15 seconds [14]. In contrast, Whitney and colleagues compared FTSTS performance in individuals with and without balance disorders and without controlling for age, the AUC was 0.75 and the cutoff score was 13 seconds [13]. In the same study, when examining only individuals age sixty or older, the AUC was 0.68 [13]. The ability of the FTSTS to discriminate between fallers and non-fallers in the current study is comparable to that of other accepted outcome measures [42,13, 43]. The results of this study support the use of the FTSTS as a quick and objective measure to determine whether or not an individual with PD may be at risk for falling.

Study Limitations and Future Research

One limitation of this study is recording only one trial of the FTSTS test. Taking a mean of two or more trials may have allowed for understanding of FTSTS performance consistency within participants. A second limitation is the small sample size used to examine test-retest reliability. Future research should examine the timed sit-to-stand test in individuals with PD over time to gain a clearer picture of how performance changes over time and how this relates to changes in postural instability and bradykinesia. Finally, our model explained only 55% of the variance in FTSTS times, suggesting that other factors not measured here also influence FTSTS performance. Future studies could incorporate the FTSTS test in a battery of outcome measures to determine if it has additive value in predicting fall risk in individuals with PD and to determine what other factors not measured here may influence FTSTS performance.

Conclusions

Timed sit-to-stand performance does not seem to be related to disease severity in individuals with PD. Performance on the FTSTS test in PD is most related to balance and bradykinesia. The FTSTS test is reliable and easy-to-administer, and maybe useful as a quick means of assessing gross fall risk in individuals with PD.

Acknowledgments

Abbreviations

PD	Parkinson Disease
FTSTS	Five Times Sit to Stand Test
QOL	Quality of Life
H&Y	Hoehn & Yahr

ICC	Intraclass Correlation Coefficient
Mini-BEST	Mini-Balance Evaluation Systems Test
MVIC	Maximal Voluntary Isometric Contraction
6MWT	Six Minute Walk Test
9HPT	Nine Hole Peg Test
FOGQ	Freezing of Gait Questionnaire
ABC	Activity Specific Balance Confidence Scale
PASE	Physical Activity Scale for the Elderly
PDQ-39	Parkinson Disease Questionnaire - 39
ROC	Receiver Operating Characteristic

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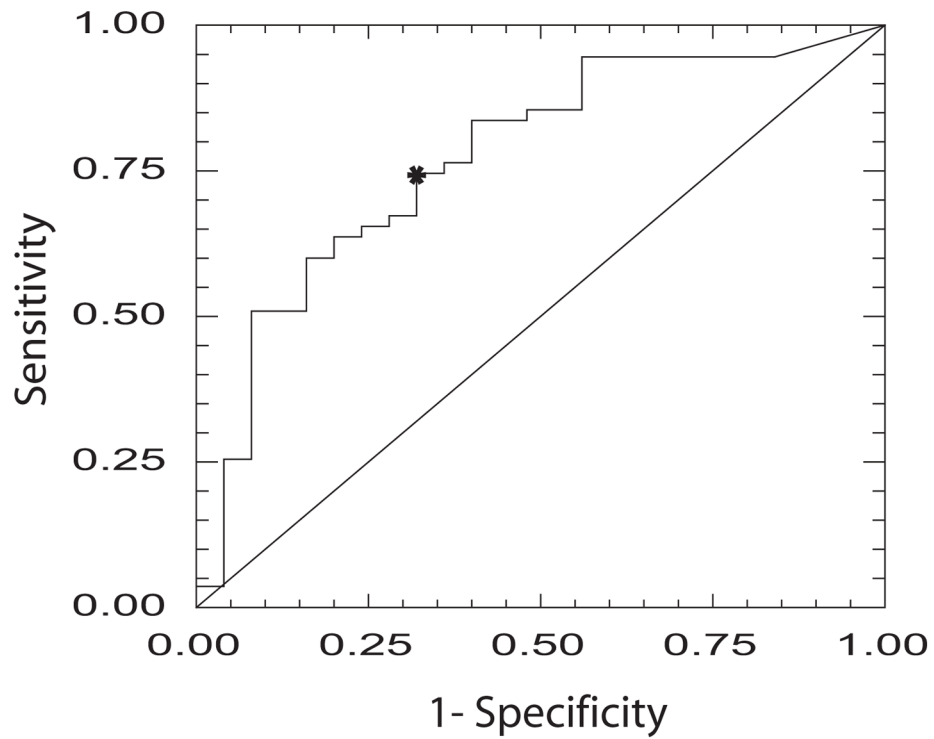**Figure 1.**
ROC curve for the FTSTS showing sensitivity and specificity for discriminating between individuals with PD with and without a history of falls. Asterisk denotes cutoff score of 16 seconds (sensitivity = .75, specificity = .68).

Table 1

FTSTS Performance by H & Y Stage.

Disease Severity	Number of Participants	Mean Time (s) ± SD
H & Y 1	4	15.39 ± 5.81
H & Y 2	27	21.27 ± 14.21
H & Y 2.5	31	18.87 ± 12.68
H & Y 3	12	22.70 ± 17.73
H & Y 4	6	21.15 ± 19.32

Table 2

Correlation coefficients between FTSTS and all variables.

	Variable	Correlation	p Value
Demographics	Age	0.37	0.001
	BMI	−0.10	0.40
Questionnaires	PASE	−0.38	0.001
	PDQ-Mobility	0.58	< 0.001
	FOGQ	0.44	< 0.001
	PDQ-SI	0.38	0.001
	ABC	−0.54	< 0.001
Mobility Measures	Mini-BEST	−0.71	< 0.001
	Quadriceps MVIC	−0.33	0.003
	9HPT	0.55	< 0.001
	6MWT	−0.60	< 0.001

[*] Pearson correlations were used for all measures.

Abbreviations: BMI – body mass index, PASE – Physical Activity Scale for the Elderly, PDQ-Mobility – Parkinson Disease Questionnaire – Mobility, FOGQ – Freezing of Gait Questionnaire, PDQ-SI – Parkinson Disease Questionnaire – Summary Index, ABC – Activities Specific Balance Confidence Scale, Mini-BEST – Mini-Balance Evaluations Systems Test, Quadriceps MVIC – Quadriceps Maximal Voluntary Isometric Contraction, 9HPT – Nine Hole Peg Test, 6MWT – Six Minute Walk Test

Table 3

Regression Analyses

	Cumulative R^2	β	*P value*
Model 1			
Mini-BEST	0.500	−0.58	<0.0001
9HPT	0.528	0.21	0.03
Model 2			
Mini-BEST	0.506	−0.69	<0.001
9HPT	0.535	0.22	0.05
PDQ-SI	0.545	−0.12	0.34
Quadriceps MVIC	0.548	−0.06	0.52
PASE	0.552	0.06	0.58
FOGQ	0.553	−0.06	0.61
6MWT	0.554	−0.06	0.73
Age	0.555	−0.03	0.77
ABC	0.555	0.00	0.99

Cumulative R^2 = total R^2 when the variable in question plus all preceding variables have been entered into the model

β= standardized regression coefficients

Abbreviations: Mini-BEST – Mini Balance Evaluations Systems Test, 9HPT – Nine Hole Peg Test, PDQ-SI – Parkinson Disease Questionnaire – Summary Index, Quadriceps MVIC – Quadriceps Maximal Voluntary Isometric Contraction, PASE – Physical Activity Scale for the Elderly, FOGQ – Freezing of Gait Questionnaire, 6MWT – Six Minute Walk Test, ABC – Activities Specific Balance Confidence Scale