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Validity and Reliability of the 4 Meter Walk Test in Parkinson Disease

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Abstract

Purpose: The purpose of this study was to assess the validity and reliability of the 4-meter walk test (4MWT) in people with Parkinson disease (PD). Method: Gait velocity was measured in 25 people with PD using a computerized walkway, 10-meter walk test (10MWT), and 4-meter walk test (4MWT) under three conditions: comfortable walking speed (CWS), fast walking speed (FWS), dual task (DT). Video recording was used to assess intrarater and interrater reliability of the 4MWT. Pearson's correlation assessed validity and the intra-class correlation coefficient (ICC (2,1)) assessed intrarater and interrater reliability.

Results: There was a significant correlation between the computerized walkway and the 4MWT for all conditions, CWS ($r = 0.87$, $p < 0.001$), FWS ($r = .67$, $p = 0.002$), and DT ($r = .78$, $p < 0.001$). There was significant correlation between the 10MWT and the 4MWT for all conditions, CWS ($r = 0.80$, $p < 0.001$), FWS ($r = .66$, $p < 0.001$), and DT ($r = .50$, $p = 0.013$). All reliability tests were significant at $p < 0.001$. Intrarater reliability values were very high for CWS (ICC (2,1) = 0.91, [.73-.97]), FWS (ICC (2,1) = 0.99, [0.98-0.99]), and DT (ICC (2,1) = 0.96, [0.88-0.98]). Interrater reliability values were high for CWS (ICC (2,1) = 0.90, [0.73-0.96]), FWS (ICC (2,1) = 0.99, [0.98-0.99]), and DT (ICC (2,1) = 0.95, [0.87-0.98]).

Conclusion: The 4MWT is a valid and reliable tool to measure gait velocity in individuals with PD.

Introduction

Parkinson disease (PD) is a progressive neurodegenerative disorder representing a common pathology related to aging, affecting more than six million individuals worldwide[1-3]. While PD is a complex condition that can vary in clinical presentation and progression, it is often characterized by both motor and non-motor symptoms. Commonly tremor, rigidity, bradykinesia, and postural instability are considered cardinal characteristics of the disease. Individuals with PD exhibit gait disturbances including decreased velocity and step length, high cycle time variability, difficulty turning, and freezing of gait[4]. The management of people affected with PD presents caregivers and healthcare systems with a considerable burden, thus there is a need to investigate efficient and effective outcome measures to capture function and disease progression[5,6].

Gait velocity is considered an important clinical indicator of function in older adult populations as it can potentially predict an individual's future health status or mortality[7]. Studenski et al[7] found that a gait velocity of 0.8 meters/second was predictive of median life expectancy in older adults, with slower gait speeds leading to a decreased life expectancy. Increased demands of walking and lower muscle force production in older adults may contribute to this relationship. Factors leading to slower gait in people with PD include poor mobility, balance deficits, fear of falling, history of falls, cognition, age, and advanced disease[8]. A simple and reliable measurement of gait speed is imperative for health providers to accurately assess this component of function and health.

Current methodologies to measure gait speed in individuals with PD include observable clinician-administered performance measures such as the 10-meter walk test (10MWT) as well as more sophisticated computerized gait analysis. Walkway systems, such as the GAITRite walkway (CIR Systems Inc, Sparta, New Jersey) and the Zeno Walkway Gait Analysis System (ProtoKinetics LLC, Havertown, Pennsylvania), "use embedded sensors to collect foot pressures during gait, which are processed with associated software to compute spatiotemporal gait parameters"[9]. As the cost of computerized walkway systems can be prohibitive, clinicians often use 10MWT to assess gait speed[8]. As described by Wolf et al[10], the 10MWT allows for participants to attain their normal gait speed as they traverse the center six meters of a 10-meter walkway. The 10MWT is a reliable tool for testing gait speed in people with PD and can be implemented to measure both fast walking ($ICC_{2,1} = 0.99$) and comfortable walking speeds ($ICC_{2,1} = 0.98$)[11]. Combs et al[11], found the 10MWT to be a valid measurement assessing the decline in walking speed across the stages of disease progression in persons with PD. Comfortable gait speed was tested using the 10MWT in participants diagnosed with PD showing excellent test-retest reliability (ICC ≥ .96), along with comfortable and fast gait speeds showing excellent reliability between sessions (ICC = 0.92 and 0.96, respectively)[12,13].

The 10MWT requires an unobstructed, level pathway of at least 10 meters which can present a barrier to its utility in hospital rooms or patient's homes. While only the center six meters is timed to allow for an acceleration and deceleration period, the entire test requires the full 10 meters of space[10]. One option to overcome the barriers inherent to the 10MWT is to use the 4-meter walk test (4MWT). The 4MWT requires less space and therefore may offer more versatility for use across settings. Additionally, the decrease in required distance of ambulation may allow for assessment of gait speed in patients with lower levels of functional mobility and endurance. While the 4MWT has shown excellent test-retest reliability in healthy older adults (with and without cognitive impairment) and people after lower extremity surgery, findings have not shown sufficient concurrent validity with the 10MWT in these populations[14,15]. In individuals with chronic stroke, the 4MWT demonstrates excellent test-retest reliability, concurrent validity, and strong correlation with the 10MWT at comfortable walking speed[16]. However, there remains a lack of research on the reliability and validity of the 4MWT in people with PD. To our knowledge, no studies have attempted to establish concurrent validity between the 4MWT and with a computerized walking in people with PD.

The purpose of the study was to determine the concurrent validity, interrater reliability, and interrater reliability of the 4MWT in people with PD. Our hypotheses were two-fold: 1) the 4MWT would demonstrate concurrent validity via a significant correlation with a computerized walkway system and the 10MWT, and 2) the 4MWT would demonstrate significant intrarater and interrater reliability.

Methods

Participants

Incorporating research assessing the validity of gait parameters using a computerized walkway in individuals with PD, a sample of 20 participants were determined to be necessary for significance and to account for attrition[17]. A power calculation and previous research determined a sample size of 10-12 participants was necessary for the reliability portion of the study[12,18,19]. A convenience sample of 25 individuals with PD were recruited for this study. The inclusion criteria were: 1) individuals diagnosed with PD in Hoehn and Yahr stages I – IV; 2) ability to walk independently for at least 5 minutes; and 3) alert and oriented to person, place and time. The exclusion criteria were: 1) Deep-Brain Stimulation surgery less than 24 months prior to the start of the study; 2) changes in Deep-Brain Stimulation parameters during the study; 3) acute orthopedic injury or surgery that could impact gait; and 4) a neurological condition other than PD. All participants completed testing within 2 hours of taking their regularly scheduled medications for PD (ON phase). The study was approved by a university Institutional Review Board and all participants signed an informed consent.

Procedures

Computerized walkway mats are valid and reliable tools for measuring the spatiotemporal parameters of gait[20]. The Zeno Walkway System (Zeno mat) with ProtoKinetics Movement Analysis Software has a high level of consistency with the GAITRite walkway for spatiotemporal parameters (ICC > 0.84). Additionally, the GAITRite has been validated to motion analysis systems for comparing gait in individuals with PD[21].

Participants completed walking trials on the Zeno mat and overground using the 10MWT and 4MWT to measure gait velocity. To measure gait velocity using the computerized walkway, the participants were instructed to walk across the mat at their preferred walking speed. Participants were instructed to start off the mat at one end and walk across and off the 4.8 meter mat to a visual mark the other end, turn and stand until instructed to walk the length of the mat again. This set up allowed for 1 meter of gait acceleration and deceleration distances to occur outside the computerized walkway. The instructions promoted uniformity and encouraged the participants to walk through the entire length of the mat at a consistent pace. The 10MWT was set up as a marked runway of 10 meters on a smooth, flat surface. The middle six meters were timed using a stopwatch with the initial and final two meters serving as an area for acceleration and deceleration as this set up has shown to be optimal in the neurologic population[22]. The 4MWT was set up in the same manner except the runway was six meters and the middle four meters were timed[15]. Despite the slight differences in set up between the 4MWT and 10MWT, both were administered following guidelines used in previous research. The computerized walkway and testing set up was similar at both locations and remained consistent throughout testing.

Everyone was first fitted with a gait belt and a physical therapist provided supervision assistance at the person's side as they completed their walking trials. Participants completed three conditions on both the computerized walkway and the 4MWT consisting of: comfortable walking speed (CWS), fast walking speed (FWS), and dual task walking speed (DT). DT involved asking the participant to walk at a comfortable speed while counting backward by sevens starting from 100. Each condition was completed three times, and the average of the three scores was used for analysis. For DT testing, continuous subtracting continued throughout all three trials to reduce the practice effect.

During all conditions of the 4MWT, the participants were video recorded while in-person testing was being completed. The video was filmed in the same position and view as the in-person tester to ensure consistency with scoring. Five physical therapists with at least 6 years of experience each participated as testers. Data was collected in 2 locations that were set up in the same format. The videos were scored by the same tester at least 1 week after testing and scored by a different tester within 3 weeks using the same scoring criteria. The method of video recording to gather data for reliability testing was used to reduce maturation, possibly of a learning effect, or fluctuations in the disease process that could impact scoring. Only 24 of the participants were included in the reliability data analysis due to a recording error for one of the participants.

Data Analysis

All statistical analyses were calculated using SPSS Statistics version 29 software (IBM Corporation, Armonk, New York). To determine concurrent validity using the strength of the relationship between the computerized walkway and 4MWT and the 10MWT, a Pearson's correlation was completed for all three conditions and a p value < .05 was used to indicate significance as normality was achieved. Correlation results were interpreted as: little or no relationship (0 to 0.25), fair relationship (>0.25 to 0.50), moderate to good relationship (>0.50 to 0.75), and good to excellent relationship (>0.75)[23].

To evaluate the interrater and intrarater reliability of the 4MWT, intra-class correlation coefficient (ICC) (2,1), 2-way random effects model with absolute consistency and values calculated with significance indicated at p < .05[24]. ICC (2,1) were analyzed with a 95% confidence interval (95%CI) and interpreted according to the following criteria: < 0.49 was deemed low reliability, 0.50 to 0.69 as moderate, 0.70 to 0.89 as high, and 0.90 to 1.0 as very high reliability[24,25]. Additionally, Bland-Altman plots and standard error of measurement (SEM) were used to display agreement[26].

Results

A total of 25 participants completed the study. Of these, data from all 25 was used to determine concurrent validity; however, data from 24 participants was used for reliability analysis due to a recording error. The sample population consisted of 13 males and 12 females with a mean (standard deviation) age of 71.3(6.7) and years since diagnosis of 6.4(4.9). The Hoehn and Yahr stages included six participants in Stage I, eight participants in Stage II, eight participants in Stage III, and three participants in Stage IV. Three participants used a rolling walker during testing. See Table 1 for dependent variable means and standard deviations.

Concurrent Validity

There was a significant correlation between the computerized walkway and the 4MWT for all conditions, representing a good to excellent relationship for CWS ($r = 0.87$, $p < 0.001$) and DT ($r = .78$, $p < 0.001$) and a moderate to good relationship for FWS ($r = .67$, $p = 0.002$).

There was significant correlation between the 10MWT and the 4MWT for all conditions, representing a good to excellent relationship for CWS ($r = 0.80$, $p < 0.001$), moderate to good relationship for FWS ($r = .66$, $p < 0.001$), and a moderate relationship for DT ($r = .50$, $p = 0.013$).

Reliability

All reliability tests were significant at $p < 0.001$. Intrarater reliability ICC (2,1) values were very high for all

Table 1: Dependent Variable Means and Standard Deviations (n = 25 validity, 24 reliability)

Condition[a]	Computerized Walkway	10MWT	4MWT [Tester 1 1st test]	4MWT [Tester 1 2nd test]	4MWT [Tester 2]
CWS[b]	1.08 (.21)	1.27 (.25)	1.27 (.25)	1.26 (.25)	1.26 (.25)
FWS[c]	1.56 (.33)	1.62 (.34)	1.62 (.34)	1.63 (.34)	1.65 (.35)
DT[d]	.99 (.24)	1.23 (.31)	1.23 (.30)	1.18 (.25)	1.18 (.26)

[a]velocity-meters/second

[b]comfortable walking speed, [c]fast walking speed, [d]dual task

three conditions of CWS (ICC (2,1) = 0.91, 95%CI [.84-.97], SEM = 0.04), FWS (ICC (2,1) = 0.99, 95%CI [0.98-0.99], SEM = 0.006), and DT (ICC (2,1) = 0.96, 95%CI [0.88-0.98], SEM = 0.02). Interrater reliability values were also very high for the three conditions of CWS (ICC (2,1) = 0.90, 95%CI [0.73-0.96], SEM = 0.04), FWS (ICC (2,1) = 0.99, 95%CI [0.98-0.99], SEM = 0.02), and DT (ICC (2,1) = 0.95, 95%CI [0.87-0.98], SEM = 0.03). Bland-Altman plots with 95% CI for reliability were constructed. The plots illustrate the agreement between raters and identifies possible outliers. Each sample is represented on the graph by conveying the mean value of the rater means (x-axis) and the differences between the 2 tests (y-axis) in seconds. The mean difference was the estimated bias, and the standard deviation (SD) of the differences measured the fluctuations around this mean using outliers above 1.96 SD difference. Reference lines show the mean difference between ratings (solid line), and 95% limits of agreement for the mean difference (dashed lines). Interrater reliability shown in Figure 1 and intrarater reliability shown in Figure 2.

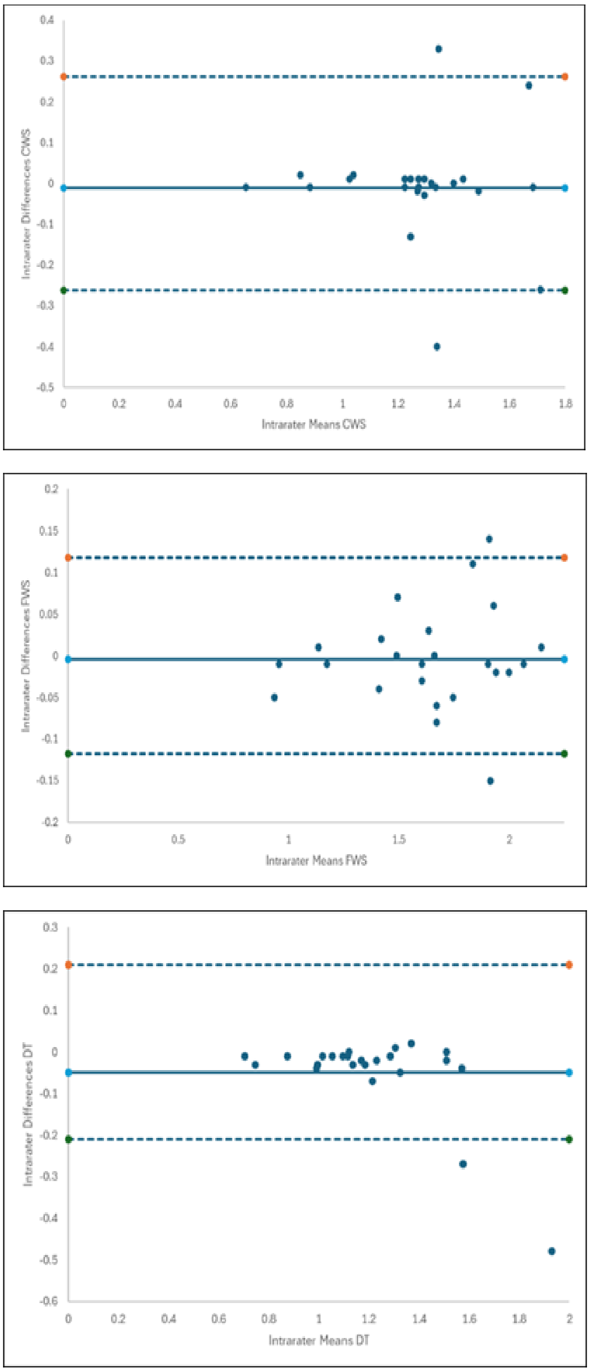

Figure 1. Intrarater reliability Bland-Altman plot

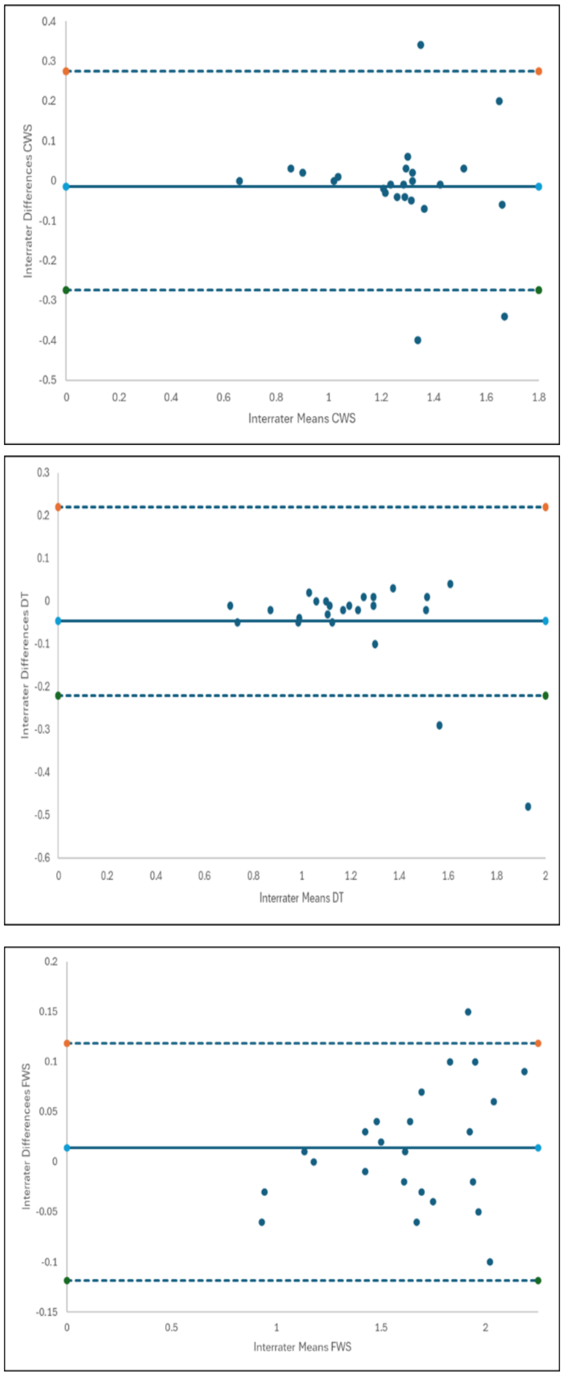

Figure 2. Interrater reliablity Bland-Altman plot

Discussion

The 4MWT was designed to measure gait velocity over a reduced distance[27,28]. The assessment of gait speed is an important predictor of potential decline in function and risk of adverse events in elderly patients[29,30]. It is estimated that 60% of people with PD experience one or more falls each year[31]. In PD, decreased gait speed and shuffling gait may be indicative of previous and future falls[31]. Not only is walking speed tied to fall risk, but it is also a determinant of ability for safe community ambulation, independence, and need for rehabilitative services[15]. As such, outcome measures that accurately assess gait speed are necessary to ensure data is meaningful. The 4MWT is increasingly being used as an independent measure in the assessment of gait speed in different populations[28]. Not only is the 4MWT recommended by the National Institute of Health toolbox as a motor domain measure of neurologic and behavioral function, normative reference values and test-retest reliability has recently been established across a sample of adults ranging from 18-85[28,32].

The present study aimed to assess the concurrent validity of the 4MWT via correlation with a computerized walkway, and the interrater and intrarater reliability when measuring gait speed using the 4MWT in people with PD. Although results revealed significant correlations between the 4MWT and the computerized walkway for the assessment of gait speed, it is important to consider the reason for the lower relationship of FWS compared to CWS or DT. There is a possibility that the distance of 4 meters was not long enough for the participants to fully achieve their fastest velocity. Participants had the opportunity to ambulate over 4.8 meters across the computerized walkway with measurement occurring throughout the full length, not just during the middle 4 meters. While freezing of gait was not observed in the participants during testing, another plausible explanation for the moderate relationship seen in the FWS condition could simply be that people with PD experience difficulty during initiation and sustentation of movement and velocity. The reduced distance of the 4MWT may have had a more detrimental impact on the ability of a person to demonstrate an increased velocity. Using a longer gait velocity measure should be considered when assessing FWS in people with PD. Additionally, while the results were significant, it is necessary to note the overall reduced mean velocity on the computerized walkway as compared to the 10MWT and 4MWT. Possible explanations for this presentation are the changes in pressure of the mat compared to the floor, color change of the surfaces, and the slightly elevated surface of the mat.

Outcome measures are a necessary clinical tool in the assessment of patients participating in physical therapy. However, studies suggest that most assessments are under-utilized in clinical settings because of potential barriers including time, lack of knowledge regarding tools, and patient ability to participate independently[33,34]. Environmental factors such as limited space have been reported as a barrier to outcome measure use in a systematic review by Jang et al[35], thus lending support to using a shorter distanced tool such as the 4MWT. Since time to perform measures is the most significant barrier to performing a clinical outcome measure, a shorter distance measure of gait speed may also reduce the clinician's total time needed to perform the measure[35].

The results of this study indicate that the 4MWT can be used as a reliable and valid outcome measure in people with PD to measure gait speed. It is important to recognize the participant population of this study consisted mostly of people in the middle stages of the disease process when generalizing the results. The 4MWT may find utility in clinical settings in which there is lack of space, limited time, or no access to a computerized walkway. Previous studies have similarly demonstrated the efficacy of assessments of gait speed over ground versus a computerized walkway[36]. Results from similarly designed studies involving populations of lower extremity surgery and stroke have reported that the 4MWT may be preferred over the traditional measure of the 10MWT to mitigate barriers such as space and time[14,16,37]. Regardless of the distance or surface, testing parameters must be kept consistent when performing a gait speed assessment.

Limitations

There were several limitations to this study. Although people with PD in Hoehn and Yahr stages I – IV who could walk independently were recruited, the sample was primarily composed of participants presenting in the Hoehn and Yahr stages II and III, potentially limiting extrapolation across all stages of disease severity. Because of the limited sample size, sub-analysis to compare results among all stages of progression could not be performed. A larger sample size could have provided more clear comparisons. Another barrier to generability is that participants were tested during the ON phase of their medicaiton regimen. Recognizing how medication mitigates motor symptoms temporarily while in the ON phase, the results from this study may not be generalizable to individuals with PD during the OFF times of medication.

Methodological limitations included the need to provide close supervision, assessing all participants while in the ON phase of their medication, and data collection occurring across 2 locations. Close supervision during the walking trials, including use of a gait belt and a physical therapist walking closely alongside the participant to ensure safety, may inadvertently have altered the participants performance. Use of an overhead harness system may reduce this potential bias but could also alter gait speed.

Lastly, although similar equipment and procedures were used to improve consistency, external threats to validity may have been introduced since data were collected in 2 separate locations, supplying slight differences of the data collection environment.

Future studies would benefit from increased representation of each Hoehn and Yahr stage as well as testing during the OFF phase of medication to ensure the psychometric properties remain stable in later stages of disease progression and when motor symptoms are more strongly present. Peters, Fritz, and Krotish[15], established validity of the 4MWT with the 10MWT in healthy older adults however, cautioned the interchangeable use of the tests since results suggested the degree of concurrent validity was not sufficient, potentially affecting the interpretation of meaningful changes in gait speed over time. It is imperative to remain consistent between assessments to ensure quality and accurate information is recorded during patient care.

Conclusions

Standardized outcome measures are critical to the integrity of physical therapy practice for demonstrating change in patient performance. Therefore, it is important to reduce the barriers of implementing outcome measures in clinical settings. The 4MWT is an outcome measure for assessing gait speed in people with PD, offering advantages in clinical settings with limited space and time, and overcoming barriers like those associated with the 10MWT and computerized walkways. The results of this study revealed strong psychometric properties of reliablity and validity in the 4MWT in people with PD as a method to assess gait velocity.

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