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Are the Average Gait Speeds During the 10 Meter and 6 Minute Walk Tests Redundant in Parkinson Disease?

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Abstract

We investigated the relationships between average gait speed collected with the 10 Meter Walk Test (Comfortable and Fast) and 6 Minute Walk Test (6MWT) in 346 people with Parkinson disease (PD) and how the relationships change with increasing disease severity. Pearson correlation and linear regression analyses determined relationships between 10 Meter Walk Test and 6MWT gait speed values for the entire sample and for sub-samples stratified by Hoehn & Yahr (H&Y) stage I (n=53), II (n=141), III (n=135) and IV (n=17). We hypothesized that redundant tests would be highly and significantly correlated (i.e. $r > 0.70$, $p < 0.05$) and would have a linear regression model slope of 1 and intercept of 0. For the entire sample, 6MWT gait speed was significantly ($p < 0.001$) related to the Comfortable 10 Meter Walk Test ($r = 0.75$) and Fast 10 Meter Walk Test ($r = 0.79$) gait speed, with 56% and 62% of the variance in 6MWT gait speed explained, respectively. The regression model of 6MWT gait speed predicted by Comfortable 10

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Meter Walk gait speed produced slope and intercept values near 1 and 0, respectively, especially for participants in H&Y stages II–IV. In contrast, slope and intercept values were further from 1 and 0, respectively, for the Fast 10 Meter Walk Test. Comfortable 10 Meter Walk Test and 6MWT gait speeds appeared to be redundant in people with moderate to severe PD, suggesting the Comfortable 10 Meter Walk Test can be used to estimate 6MWT distance in this population.

Keywords

Parkinson disease; gait; endurance; outcome measures

Introduction

Gait impairments in people with Parkinson disease (PD) are associated with decreased functional independence [1], reduced quality of life [2, 3], and increased falls [4]. Gait assessment is considered a critical part of the PD clinical examination, given that difficulty with ambulation has been proposed as a “clinical ‘red flag’ that precipitates emerging disability,” [1]p. S134 and a recent report suggesting gait speed is associated with mortality in older adults [5]. Gait assessment tools, however, are highly variable in administrative burden. Preferably, their selection for use in people with PD should be based at least in part on the degree to which they provide unique information about walking performance.

The 10 Meter Walk Test and 6 Minute Walk Test (6MWT) are commonly employed clinical gait assessment tools. The 10 Meter Walk Test explicitly measures average gait speed (hereafter referred to as “gait speed”) at a single pace (i.e. comfortable or fast) over a short distance and requires only a few minutes to complete [6]. In contrast, the 6MWT measures walking endurance at a self-determined pace over a long distance (i.e. “cover as much ground as possible in 6 minutes”) [7]. The 6MWT requires approximately 10 minutes to administer and gait speed values are derived secondarily from distance walked. Although short-distance gait speed can discriminate between people with mild and moderate levels of PD severity [8], it is unknown whether and how the relationships between gait speeds collected in the 10 Meter Walk Test and 6MWT change across different stages of the disease.

Studies of people with stroke and spinal cord injury indicated that gait speed measured with the 10 Meter Walk Test often overestimated gait speed determined with the 6MWT [9–11]. This evidence suggests that the gait speed generated by each test may not be redundant. The question of information redundancy becomes more complicated when examining the gait speed of people with PD, in whom hypokinesia increasingly may limit the ability to sustain a fast walking pace as the disease progresses [12]. Investigators reported, for example, that people with PD were only able to maintain their fast-as-possible short-distance gait speed 76% of the time during the 6MWT [13]. However, this study included only 16 people with mild to moderate PD. As such, questions remain related to the walking strategy used by people with PD during the 6MWT.

We aimed to determine whether or not the 10 Meter Walk Test and 6MWT are redundant measures of gait speed in PD. The second aim of the study was to determine how the

relationships between the aforementioned variables change with increasing disease severity. We hypothesized that the tests (i.e. 10 Meter Walk Test and 6MWT) would not be redundant measures of gait speed, as indicated by relatively small proportions of variance explained by linear regression models. We also hypothesized that the relationship between gait speeds on the 10 Meter Walk Test and 6MWT would strengthen as disease severity worsened, as evidenced by the 10 Meter Walk Test speed accounting for a greater proportion of the variance in 6MWT gait speed values. If the 10 Meter Walk Test and 6MWT are redundant, clinicians may choose to conduct the 10 Meter Walk Test in order to gain insight into the distance a patient may walk in the 6MWT.

Methods

Participants

Participants in this cross-sectional, secondary data analysis were pooled from a large, multi-center longitudinal study examining the progression of disability in people with PD [14] and a longitudinal study examining the effects of boxing at the University of Indianapolis [15]. For the interventional study [15], only baseline testing data were used. We included participants who were over age 30, diagnosed with clinically-defined “definite” PD [16–18], determined to be in Hoehn & Yahr (H&Y) stage I–IV [19], and able to walk unassisted for 10 meters with or without a device. Participants in H&Y stage V or with deep brain stimulation, atypical parkinsonism, a musculoskeletal injury limiting their ability to walk, or any serious medical condition were excluded. Institutional review board approval was obtained at each participating institution. All participants provided informed consent.

Measures

Participants completed one trial of the 10 Meter Walk Test at a comfortable speed (Comfortable 10 Meter Walk Test), the 10 Meter Walk Test at a fast speed (Fast 10 Meter Walk Test), and the 6MWT. For the 10 Meter Walk Test, two end lines and two buffer lines were taped on the ground. Each end line was 14 meters from the other and the each buffer line was 2 meters from the end line. The buffer lines controlled for acceleration and deceleration. The time to walk the middle 10 meters was recorded using a stopwatch. For the Comfortable 10 Meter Walk Test, participants were instructed to walk at their self-perceived comfortable pace. For the Fast 10 Meter Walk Test, participants were instructed to “walk as fast as possible without running.” The purpose of the 10 Meter Walk Test is to obtain a self-perceived (comfortable or fast-as-possible) gait speed over a short distance. For the 6MWT, participants walked in a long hallway with two lines taped 100 feet apart [7]. Participants were instructed to walk between these lines while trying to cover as much ground as possible in 6 minutes. Time continued to elapse during rest breaks, if taken. The distance covered in 6 minutes was recorded to the nearest foot and then converted to meters. The primary purpose of the 6 Minute Walk Test is to obtain a submaximal estimate of aerobic endurance during overground walking. Previous work has shown excellent inter-rater reliability for timed walking tests in people with PD [20, 21], the elderly [22], and in people with spinal cord injury [23]. For all tests, use of an assistive device was allowed, and raters stood behind the participants to avoid influencing walking performance. All participants

were tested in the on-phase of their usual anti-PD medications, defined as 1–2 hours post-medication intake [24].

Data Analysis

Descriptive statistics were used to characterize the sample. Pearson correlation and linear regression analyses were used to determine relationships between 10 Meter Walk Test gait speed values and 6MWT gait speed values for (1) the entire sample, and (2) sub-groups stratified by H&Y stage ($\alpha = 0.05$). We defined the gait speed values to be redundant when the associations between gait speed values from the 10 Meter Walk Test (comfortable and fast) and 6MWT were strong and significantly correlated (i.e. $r > 0.70$, $p < 0.05$) [25] and had a linear regression model slope of 1 and intercept of 0. Data from the linear regression models were checked to ensure linear relationships, homoscedasticity, independence of observations, normality of regression residuals, and to determine outliers.

Results

Regarding the diagnostics of the regression analyses, linear relationships between 6MWT gait speed values and both comfortable and fast 10 Meter Walk Test gait speed values were confirmed (i.e., cubic and quadratic models overlaid on scatterplots of independent variable (IV) vs. dependent variable (DV) or standardized residual vs. standardized predicted value did not substantially alter fit). Scatterplots also demonstrated standardized residuals were not distributed in a patterned way with either standardized predicted values or IVs indicating acceptable homoscedasticity.

Independence of observations was confirmed by Durbin-Watson values of 1.72 and 1.80, respectively, for comfortable and fast 10 Meter Walk Test gait speed data ordered by participant number. In addition, scatter plots of standardized residuals vs. IV were randomly and symmetrically distributed around zero with no correlations. Histograms and P-P plots demonstrated residuals were approximately normally distributed.

Of the 346 participants, 2 outliers (value $>3SD$ outside the mean) were identified in the comfortable 10 Meter Walk Test model, and 4 were identified in the fast 10 Meter Walk Test model. With separate regression casewise diagnostics, 6 outliers with residuals $>3SD$ outside the mean were identified in the comfortable 10 Meter Walk Test model, and 5 were identified in the fast 10 Meter Walk Test model. Removing outliers based on raw values or residuals had minimal impact on the regression models, and there was no substantive basis for exclusion, so all participants were included in the final analyses. Further, the maximum Cook's Distance was 0.10 for comfortable 10 Meter Walk Test and 0.08 for Fast 10 Meter Walk Test, indicating there were no overly influential cases in these models.

Across the entire sample, Comfortable (Table 2, Supplemental Figure 1) and Fast (Table 2, Supplemental 1) 10 Meter Walk Test gait speeds were significantly related to gait speed derived from the 6MWT ($p < 0.001$), with a moderate amount of variance in 6MWT gait speed values explained ($F(1,344)=452.17$, $p < 0.001$; $F(1,344)=533.44$, $p < 0.001$, respectively). Slope values indicated that 6MWT gait speed increased 1.01 m/sec and 0.65

m/sec for each 1.00 m/sec increment in Comfortable and Fast 10 MWT gait speed, respectively.

When stratified by H&Y stage, Comfortable 10 Meter Walk Test gait speed (Table 3, Supplemental Figure 2) was more strongly related to 6MWT gait speed for participants in stages II, III, and IV compared to stage I. Furthermore, slope and intercept values were relatively closer to 1 and 0, respectively, for participants in stages H&Y II, III, and IV.

When stratified by H&Y stage, Fast 10 Meter Walk Test was moderately to strongly related to 6MWT gait speed (Table 4, Supplemental Figure 3), particularly in stages II and III compared to stages I and IV. Compared to Comfortable 10 Meter Walk Test, slope and intercept values were relatively further from 1 and 0, respectively, across all H&Y stages.

Discussion

To our knowledge, this was the first study to examine the relationships between 10 Meter Walk Test (Comfortable and Fast) and 6MWT gait speed values in a large sample of people with PD. Regarding our first aim, the results indicated that irrespective of disease severity, Comfortable and Fast 10 Meter Walk Test gait speed values explained 56% and 62% of the variance in 6MWT gait speed values, respectively. When examining the slope and intercept values of the regression model, the Comfortable 10 Meter Walk Test gait speed and 6MWT gait speed appeared to provide largely redundant information related to gait speed in people with moderate PD. Specifically, a gait speed increase of 1.01 m/sec in Comfortable 10 Meter Walk Test corresponded to a predicted increase of 1.01 m/second in 6MWT. This was not the case for the Fast 10 Meter Walk Test, which appeared to provide less redundant information on gait speed when compared to the 6MWT. This result was in contrast to those of previous studies that compared gait speed values derived from short and long distance walking tests in other populations [9–11].

Regarding our second aim, we determined that the relationship (i.e. correlation coefficient, slope, and intercept) between the gait speed values of the Comfortable 10 Meter Walk Test and 6MWT strengthened with increasing disease severity. In this sense, greater disease severity appeared to yield greater redundancy of gait speed values obtained from each test. Again, a gait speed increase of 0.99 m/sec in Comfortable 10 Meter Walk Test corresponded to a predicted increase of 0.99 m/sec in 6MWT for H&Y III and IV. Further, the gait speed values in Table 1 indicated that those with moderate to severe PD performed the 6MWT at a gait speed near their Comfortable 10 Meter Walk Test gait speed. In contrast, while the gait speed values for the Fast 10 Meter Walk Test and 6MWT were highly correlated, the regression line slope and intercept values were different enough from 1 and 0, respectively, to suggest that the gait speed values were not redundant. Thus, regardless of disease severity, Fast 10 Meter Walk Test gait speed provided unique information about gait speed not captured using the 6MWT. This was surprising, because participants performing the 6MWT were instructed to “cover as much ground as possible,” which implies walking at or near maximal speed.

Importantly, the regression models appeared to demonstrate a plateau effect at H&Y IV such that the relationship between both comfortable and fast 10MWT with the 6MWT speed did not increase to the extent that it did across lower H&Y stages. One potential explanation for this was the small number of participants classified at H&Y IV. It is clear when examining the confidence intervals for the regression values (Tables 3 and 4) that there was a greater degree of variability in this group compared to the others. It was unclear whether or not a larger number of participants in H&Y IV would have altered this observed plateau effect.

Multiple factors were likely to have contributed to the study results. First, hypokinesia, which can increase with sustained, repetitive behaviors like walking, may have constrained gait speed during the 6MWT [13]. Hypokinesia also worsens with more severe PD [26] and may have prevented the generation of larger differences between self-selected and fast walking paces. Second, instructions to participants differed between the tests. The interpretation of the 6MWT instructions (i.e. “cover as much ground as possible in 6 minutes”) may be more ambiguous than those of the Comfortable or Fast 10 Meter Walk Test, which explicitly require the participants to walk at a self-selected or fast-as-possible pace, respectively. Third, Christiansen and associates reported that people with PD had higher energetic costs for walking compared to healthy controls [27]. How walking economy changes in those with more severe PD is unclear; however, it is possible that worsening of walking economy with increasing PD severity could have accounted for lower 6MWT speeds. Finally, balance, which worsens over time in PD and is related to 6MWT performance in PD [28], may have played a role in the relationship between Comfortable and Fast 10 Meter Walk Test and 6MWT in H&Y II, III, and IV. Our study findings further highlight the idea that people with PD may use different strategies when engaging in short-distance versus long-distance walking bouts.

Our results had important clinical implications regarding the selection of gait measures for use with patients with PD. Given that the Comfortable 10 Meter Walk Test and 6MWT appeared to provide redundant information about gait speed for people in H&Y Stages II – III, there may not be a strong rationale for conducting both tests. That is, our data suggested that clinicians may use the Comfortable 10 Meter Walk Test gait speed to accurately predict 6MWT gait speed and, in turn, 6MWT distance in individuals with moderate PD. Presumably clinicians under time constraints would prefer the shorter of the two instruments (i.e., 10 Meter Walk Test), which may reduce the burden patients with PD susceptible to fatigue. Because the findings have not been reproduced in an external sample with PD, the results should be interpreted with caution as it is unclear whether a short distance walking test may be used as a proxy measure for cardiorespiratory fitness. In contrast, because the Fast 10 Meter Walk Test and 6MWT each appeared to provide unique information about gait speed regardless of disease severity, the rationale for their combined use would be particularly strong for clinicians seeking comprehensive insight into patients’ maximum gait speed capacity and the impact of gait-related hypokinesia. Finally, because 6MWT speed could not be fully explained by simple, short tests of walking speed, our results suggested that clinicians should continue to assess other factors (i.e. balance) that may play a role in 6MWT performance.

Study Limitations

The results of this study should be interpreted in light of its limitations. First, Unified Parkinson Disease Rating Scale motor subsection scores were not collected, which limited our ability to comprehensively characterize the motor severity of our sample. However, the H&Y scale is widely used [29] and has served as a reference standard for development of rating scales related to impairment and disability in PD [30]. Second, approximately 5% of participants, across all stages, except for H&Y I, used an assistive device for the 6MWT, but not for the 10 Meter Walk Test. We recognize that this may have impacted 6MWT performance, but encouraged participants to use a device if they needed it for safety reasons. Third, reliability testing was not conducted for this study; however, previous studies have reported excellent interrater reliability of timed walking tests (10 Meter Walk Test and 4-Meter Walk Test, respectively) in the elderly [22] and in people with spinal cord injury [23]. Fourth, we recognize that raters were not blinded to H&Y stage of participants. Given the nature of the testing protocol, it was difficult to blind a rater from a participant's difficulty or lack thereof with gait. However, because timed walking tests are objective measures rather than subjective ratings, we think this bias was minimized. Fifth, we did not collect data related to freezing of gait, which could have impacted walking performance, particularly the 6MWT because it requires turning. Future studies should include this and evaluate the effect of freezing on gait speed collected in the 10 Meter Walk Test and 6MWT. Additionally, our sample included a relatively small number of participants at H&Y IV. In the future, investigators should include more participants at this stage to confirm the relationships between these gait measures. People with PD at this stage often are more difficult to recruit, given their more advanced motor and non-motor symptoms.

Conclusion

Comfortable and Fast 10 Meter Walk Test gait speeds were related to 6MWT gait speed in people with PD. In particular, the Comfortable 10 Meter Walk Test and 6MWT provided redundant information related to gait speed, especially in those with moderate disease. This finding suggests that the Comfortable 10 Meter Walk Test gait speed values may be used to estimate 6MWT distance in patients with PD at H&Y II and III, which would be a useful clinical practice when time constraints limit the use of both tests.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Highlights

- Gait speed during the Comfortable 10 Meter Walk and 6 Minute Walk are strongly associated in moderate PD
- Comfortable 10 Meter Walk may be used to estimate 6 Minute Walk Test distance in moderate PD

Table 1

Demographics of entire sample and grouped by H&Y

	Entire Sample (n=346)	H&Y I (n=53)	H&Y II (n=141)	H&Y III (n=135)	H&Y IV (n=17)
Age	67.27 ± 9.31	63.32 ± 9.05	66.30 ± 8.77	69.39 ± 9.21	70.71 ± 10.29
Gender (% female)	40%	42%	38%	41%	35%
Years with Diagnosis	5.91 ± 4.58	4.32 ± 3.21	4.72 ± 3.77	7.30 ± 5.15	9.39 ± 4.63
10 Meter Walk Test Comfortable (m/s)	1.18 ± 0.26	1.27 ± 0.19	1.28 ± 0.21	1.08 ± 0.26	0.85 ± 0.24
10 Meter Walk Test Fast (m/s)	1.64 ± 0.41	1.83 ± 0.27	1.78 ± 0.38	1.48 ± 0.39	1.18 ± 0.43
6MWT Speed (m/s)	1.20 ± 0.34	1.34 ± 0.27	1.32 ± 0.27	1.07 ± 0.34	0.72 ± 0.33
6MWT Distance (m)	430.44 ± 123.45	482.02 ± 95.50	474.44 ± 96.83	385.99 ± 123.72	257.71 ± 120.33

Table 2

Linear regression model of 6MWT speed predicted by Comfortable and Fast 10 Meter Walk Test speeds for the whole sample.

	B (95% CI)	Intercept (95% CI)	SE B	β	r (95% CI)	R²	t	p
Comfortable 10 Meter Walk Test	1.01 (0.92, 1.10)	0.01 (-0.11, 0.12)	0.05	0.75	0.75 (0.70, 0.79)	0.56	21.26	<0.001
Fast 10 Meter Walk Test	0.65 (0.60, 0.71)	0.12 (0.03, 0.22)	0.03	0.79	0.79 (0.75, 0.83)	0.62	23.53	<0.001

B = Unstandardized regression coefficient (slope); β = standardized regression coefficient; r = Pearson correlation coefficient

Table 3

Linear regression model of 6MWT speed predicted by Comfortable 10 Meter Walk Test speed grouped by H&Y stage.

	B (95% CI)	Intercept (95% CI)	SE B	β	<i>r</i> (95% CI)	R ²	t	<i>p</i>
H&Y I	0.59 (0.24, 0.95)	0.59 (0.13, 1.04)	0.18	0.42	0.42 (0.17, 0.62)	0.18	3.34	0.002
H&Y II	0.88 (0.73, 1.04)	0.19 (-0.02, 0.39)	0.08	0.68	0.68 (0.58, 0.76)	0.47	11.04	<0.001
H&Y III	0.99 (0.84, 1.15)	0.00 (-0.17, 0.17)	0.08	0.74	0.74 (0.65, 0.81)	0.55	12.76	<0.001
H&Y IV	0.99 (0.44, 1.54)	-0.13 (-0.61, 0.36)	0.26	0.70	0.70 (0.33, 0.88)	0.49	3.82	0.002

B = Unstandardized regression coefficient (slope); β = standardized regression coefficient; *r* = Pearson correlation coefficient

Table 4

Linear regression model of 6MWT speed predicted by Fast 10 Meter Walk Test speed grouped by H&Y stage.

	B (95% CI)	Intercept (95% CI)	SE B	β	r (95% CI)	R ²	t	p
H&Y I	0.61 (0.39, 0.83)	0.22 (-0.19, 0.64)	0.11	0.61	0.61 (0.41, 0.76)	0.37	5.49	<0.001
H&Y II	0.53 (0.46, 0.61)	0.37 (0.23, 0.51)	0.04	0.75	0.75 (0.67, 0.81)	0.56	13.41	<0.001
H&Y III	0.68 (0.58, 0.78)	0.06 (-0.09, 0.21)	0.05	0.77	0.77 (0.69, 0.83)	0.59	13.85	<0.001
H&Y IV	0.46 (0.11, 0.80)	0.18 (-0.25, 0.61)	0.16	0.59	0.59 (0.15, 0.83)	0.35	2.81	0.013

B = Unstandardized regression coefficient (slope); β = standardized regression coefficient; r = Pearson correlation coefficient