

Do Clinical Scales of Balance Reflect Turning Abnormalities in People With Parkinson's Disease?

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Background and Purpose: It is well known that people with Parkinson's disease (PD) have significant difficulty turning, and that such difficulty is related to freezing episodes and falls. However, it is unclear how clinicians should evaluate turning. The purpose of this exploratory study was to determine whether the common clinical assessment instruments reflect turning deficits in persons with PD compared with an instrumented measure.

Methods: Forty-six participants with PD (23 with mild PD, and 23 with severe PD), and 40 healthy controls were assessed using the Berg Balance Scale (Berg), Tinetti Mobility Test (Tinetti), Activities-Specific Balance Confidence Scale, and the new instrumented Timed Up & Go test using wearable inertial sensors.

Results: Turns during the instrumented Timed Up & Go test showed significant differences among groups ($\chi^2 = 43.6$, $P < 0.0001$). Specifically, controls and mild PD ($P < 0.001$) and controls and severe PD ($P < 0.00001$). The number of steps ($\chi^2 = 32.1$; $P < 0.0001$) and peak speed ($\chi^2 = 31.9$; $P < 0.0001$) during turning were significantly different among all groups. Clinical scales were less likely to detect these differences. Of the clinical scales, the Berg was best able to detect differences between control and mild PD groups. Correlations between clinical measures of balance and instrumented turning were moderate but significant.

Conclusions: We show evidence that turning is impaired, even in mildly impaired participants with PD and that this deficit is not obviously reflected in common clinical scales of balance such as the Berg

or Tinetti. It may be more useful for a clinician to examine particular items within the Berg or the turning component of the TUG if turning difficulty is suspected.

Key words: *balance disorders, gait, Parkinson's disease, turn*

(*JNPT* 2012;36: 25–31)

BACKGROUND AND PURPOSE

Even in the early stages of the disease, people with Parkinson's disease (PD) have turning deficits; severe turning deficits relate to freezing episodes and falls.^{1–3} Traditionally, evaluation of turning either is imbedded within a larger scale of balance or is not directly assessed in a physical therapy evaluation. For example, clinicians may assess turning by performing the Timed Up & Go (TUG) test, which includes a 180° turn⁴ or with the Berg Balance Scale (Berg)⁵ or the Tinetti Mobility Test (Tinetti) Motor assessment,⁶ and both include a 360° turn. Many physical therapists also use a stopwatch to time a 360° turn and count the number of steps during a turn, but quantification of turning in real time is difficult and unreliable.² There is currently no standardized way for clinicians to evaluate and characterize turning.

Turning is complex and many studies have attempted to define abnormalities of turning in people with PD. Laboratory studies have demonstrated abnormal spatial and temporal turning strategies in people with PD.⁷ People with moderate to severe PD require more steps to turn and have longer turning durations, narrower base of support, and abnormal intersegmental rotation during turns.^{8–10} In addition, turning deficits do not necessarily improve with levodopa medication.¹¹ A study by Carpinella et al¹² revealed abnormal, en bloc turning even in people with mild PD who do not have gait abnormalities. They also found a longer duration of the first turn step in the PD group, suggesting that these individuals experience a greater difficulty in the initiation, rather than in the termination, of the turning action. Furthermore, it has been reported that trunk rotation during turns has smaller angular velocities for participants with PD than for age-matched controls.¹³

The TUG is one of the most commonly used clinical tests that include assessment of turning. The TUG was designed to evaluate the speed of a sequence of mobility tasks including sit-to-stand, straight ahead walking, a 180° turn, and sit into a chair.^{4,14} However, the total time a person requires to execute the TUG may not be sensitive to subtle mobility disorders.

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This study was previously presented at Combined Sections Meeting, American Physical Therapy Association, San Diego, 2010.

Disclosure of funding: National Institutes of Health (Bethesda, Maryland) and Kinetics Foundation (Los Altos, California).

Drs. Horak and Salarian have a significant financial interest in and/or are employees of ADPM, a company that may have a commercial interest in the results of this research and technology. This potential institutional and individual conflict has been reviewed and managed by Oregon Health & Science University. All other authors declare no conflict of interest.

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ISSN: 1557-0576/12/3601-0025

DOI: 10.1097/NPT.0b013e31824620d1

A recent study showed that the TUG time does not discriminate between PD patients who fell and those who did not fall in the on-medication state.¹⁵ A study by our group showed that 12 early, untreated participants with PD who have normal TUG times nevertheless showed significantly increased turn durations, decreased peak velocity of turns, and more steps during 180° turns¹⁶ compared with people of similar age without PD. We presented a new, instrumented TUG (iTUG) test, using wearable inertial sensors, that is a reliable, valid, and sensitive method to measure the turning portion of the TUG.¹⁷ The iTUG uses automatic algorithms to quantify more than 54 metrics from the TUG.¹⁸ However, it is unknown whether other, commonly used clinical tests of balance such as the Berg and Tinetti tests could also detect turning problems in the early stages of PD without the instrumented measures.

Given the well-documented and early problems of turning in people with PD, it is important to consider how well physical therapists are evaluating turning ability in the clinic, even for those with mild PD. The purpose of this exploratory study was to determine whether the common clinical assessments of gait and upright mobility reflect turning deficits in persons with PD. Comparisons were based on how well these measures differentiated between those with PD and those without PD, between mild and severe PD, and how the measures correlated with instrumented measures of gait and turning as captured by the iTUG.

METHODS

Forty-six people with PD and 40 people without PD participated in this study. The participants in this study were part of a larger clinical study in which instrumented mobility measures are currently being developed. Therefore, the group here represents a convenience sample of participants with and without PD. Participants were excluded from the study if they had prior orthopedic injuries or impairments that could interfere with mobility (eg, artificial joints, orthotic devices, or peripheral neuropathy) or obvious cognitive problems such that they could not follow directions. Healthy participants were excluded if they had any of the previously mentioned disqualifications or any type of neurologic disorder. Participants provided written informed consent to participate in the study, which had been approved by the Oregon Health & Science University institutional review board. Characteristics of the study group are given in Table 1.

Protocol

All participants underwent a 2- to 3-hour mobility assessment, which included clinical assessments, questionnaires, and quantitative assessment of balance and mobility, using instrumented testing. Testing was conducted at the Movement Disorders Clinic at Oregon Health and Science University. All testing was performed in a fixed order within a 1-hour period, with rest breaks given as needed. All PD participants took their anti-Parkinson medication as normally indicated and were tested in the ON state. Only 4 PD participants in the study were not taking anti-Parkinson medication. All tests were administered by a physical therapist trained in the standardized administration of the assessments.

Clinical Assessments

Unified Parkinson's Disease Rating Scale

The Unified Parkinson's Disease Rating Scale (UPDRS)¹⁹ is one of the most commonly used clinical tests for PD and was used to determine severity of disease.²⁰ The motor component of this test quantifies the effects of PD on speech, facial expression, tremor at rest, action tremor, rigidity, finger taps, hand movements, hand pronation-supination, leg agility, arising from chair, posture, gait, postural stability, body bradykinesia, and dyskinesia.¹⁹ This test has 14 items each scored from 0 (*not affected*) to 4 (*most severely affected*), with a maximum total score of 108.

Hoehn and Yahr Scale

Hoehn and Yahr Scale (H&Y) is a rating scale of disease progression for PD.²¹ It is the most commonly used method for rating the severity of the disease using a staging assessment.²⁰ The 1-item scale ranges from 0 (*no symptoms of PD*) to 5 (*confined to a wheelchair*). The PD participants were divided into a mild group and a severe group as determined by the H&Y with mild defined as scores of 1 to 2 and severe defined as scores of 3 to 4.²¹ Since a score of 3 indicates failure to recover from a backward pull on the shoulders, the severe group had clinically apparent balance problems.

Berg balance scale

The Berg is a 14-item test designed to measure the balance of older adults by assessing their performance of specific functional tasks.⁵ Each task is scored from 0 to 4, for a total of 56 points. The literature indicates that a score from 41 to 56 is a low fall risk, 21 to 40 is a medium fall risk, and 0 to 20 is high fall risk.⁵ We analyzed individual items as well as the overall score.

Tinetti mobility test

The Tinetti⁶ is a reliable clinical test for measuring balance and gait in older individuals. It has 17 items divided into 2 sections: balance (0–16) and gait (0–12), for a total score of 28. Individuals scoring 19 to 24 points have been shown to have a “moderate” risk for falling and individuals scoring less than 19 points have a “high” risk for falling.²²

Questionnaires

Activities-specific balance confidence scale questionnaire

The Activities-Specific Balance Confidence Scale Questionnaire (ABC) is a reliable method for detecting loss of balance confidence in an aging population, specifically those with PD.²³ It is a 16-part questionnaire with a scale ranging from 0 to 100%; a score of less than 68% indicates low mobility.²⁴

Instrumented mobility test

The instrumented Timed Up & Go (iTUG) test is a sensitive and reliable method that included the use of inertial sensors to quantify parameters of walking and turning during the TUG test.^{16,17} The participants completed 3 trials of iTUG and the median was recorded. The test was administered in the same manner as the traditional version of the TUG, except that

Table 1. Demographics of PD and Control Participants^a

	Controls (n = 40)	Mild PD (n = 23)	Severe PD (n = 23)
Age	65.4 ± 5.5 (55-75)	64.0 ± 5.0 (57-75)	67.5 ± 8.5 (50-84)
Gender			
Male	13	10	16
Female	27	14	8
Height, cm	168.2 ± 8.2	170.9 ± 6.4	172.9 ± 9.8
Weight, kg	75.1 ± 15.5	77.9 ± 20.2	81.1 ± 14.7
UPDRS-Motor Examination	0.13 ± 0.61	18.9 ± 9.8	39.4 ± 13.3
Hoehn and Yahr Scale	0 ± 0 (0-5)	1.8 ± 0.42 (1-2)	3.5 ± 0.51 (3-5)
Time since diagnosis, y	NA	5.5 ± 3.7	14.0 ± 7.1

Abbreviations: NA, not applicable; PD, Parkinson's disease; UPDRS, Unified Parkinson's Disease Rating Scale.

^aValues are mean ± standard deviation.

the straight ahead walking component was 7 m rather than 3 m.⁴ Participants were instructed to stand up from a chair without arms, walk to the line (7 m), turn around, walk back, and sit down. Using the iTUG^{4,16,25} we measured specific turning factors: (1) duration of turn, (2) the number of steps, (3) peak speed of turn, and (4) total iTUG duration. The participant wore a portable data-receiver (X-Bus) connected with wires to 6 MTX XSens sensors (49A33G15, XSens, Enschede, the Netherlands) composed of 3D accelerometers (± 1.7 g range), and 3D gyroscopes, $\pm 300^\circ$ per second range) positioned on (i) the posterior trunk at the level of L5, near the body center of mass, (ii) one on the anterior shank of each leg, (iii) one on the dorsum side of each arm, and (iv) the sternum, 2 cm below the sternal notch.²⁶ The sensors record 3-dimensional rotational rate and acceleration at 50 Hz and the controller wirelessly streams the sensor data to a laptop. The distance of 7 m was extended from the original 3-m TUG test to provide a sufficient number of steps for gait analysis, which was determined appropriate in previous research.¹⁸ A mathematical model was used for turning analysis using the gyroscopes in the sternum sensor.²⁵ The model defined the beginning and end of turns (independent of turning speed) using rotation of the trunk in the horizontal plane. An automated analysis algorithm detected beginning of the sit-to-stand transition and, by finding the end of the turn-to-sit movement, estimated the total iTUG time.²⁵

Data Analysis

Customized software (MATLAB, MathWorks, Natick, Massachusetts) automatically detected, separated, and analyzed different components of gait and postural transition measures (sit to stand, gait, turning, and stand to sit) during the iTUG. The iTUG uses automatic analysis algorithms (licensed to APDM for their Mobility Lab system) to calculate the following metrics during the 180° turn: (1) duration of turn, (2) the number of steps, (3) peak speed of turn, (4) total iTUG duration. Turn duration was derived by integrating angular velocity in yaw measured from the gyroscope on the sternum.¹ The number of steps was derived from shank vertical accelerations and peak speed of turn by dividing 180° by the duration of the turn.^{4,16,25}

Statistical Analysis

Kolmogorov-Smirnov normality test indicated that only peak speed of turn was normally distributed ($P = 0.75$); none of the other measures had a normal distribution ($P < 0.001$ for all).

A nonparametric Kruskal-Wallis test was used to determine whether differences existed among the 3 groups on each clinical and instrumented measure (chi-square and P values are reported later). When a significant difference was found, a post hoc analysis was performed using Bonferroni adjustment ($P < 0.0083$ for 3 pair-wise comparisons) to test which groups (control, mild-PD, and severe-PD) differed from each other. Spearman rank correlation (ρ) was used to evaluate the association between clinical and instrumented scores, and between different clinical scales. Turning-related measures as well as total iTUG time were selected a priori for statistical analysis. All the analyses were performed using NCSS Software (Kaysville, Utah).

RESULTS

Instrumented Timed Up & Go

Instrumented measures clearly demonstrated deficits in turning, even in the mild PD group, and the iTUG values differed between groups. The mean (SD) time to complete the iTUG was 16.6 (2.3) seconds for control participants, 18.7 (2.7) seconds for participants with mild PD, and 23.5 (7.0) seconds for those with severe PD. The overall iTUG time in seconds, obtained from sensor data during the extended version of the TUG, was significantly different between groups ($\chi^2 = 30.0$; $P < 0.0001$). There was a significant difference in the total iTUG duration between control participants and those with mild PD ($P = 0.005$), as well as a significant difference between those with mild versus severe PD ($P < 0.00001$). Gait velocity was 11% slower in the mild PD group compared with controls, whereas the turn time in the mild PD group was 23% slower than that in the control group, suggesting that the longer turn duration contributed a larger component of the difference between the groups.

Figure 1 shows the differences between each group (control participants, those with mild PD, and those with severe PD for both the instrumented and clinical measures). The mean (SD) time to complete a turn was 1.95 (0.06) seconds for control participants, 2.5 (0.09) seconds for participants with mild

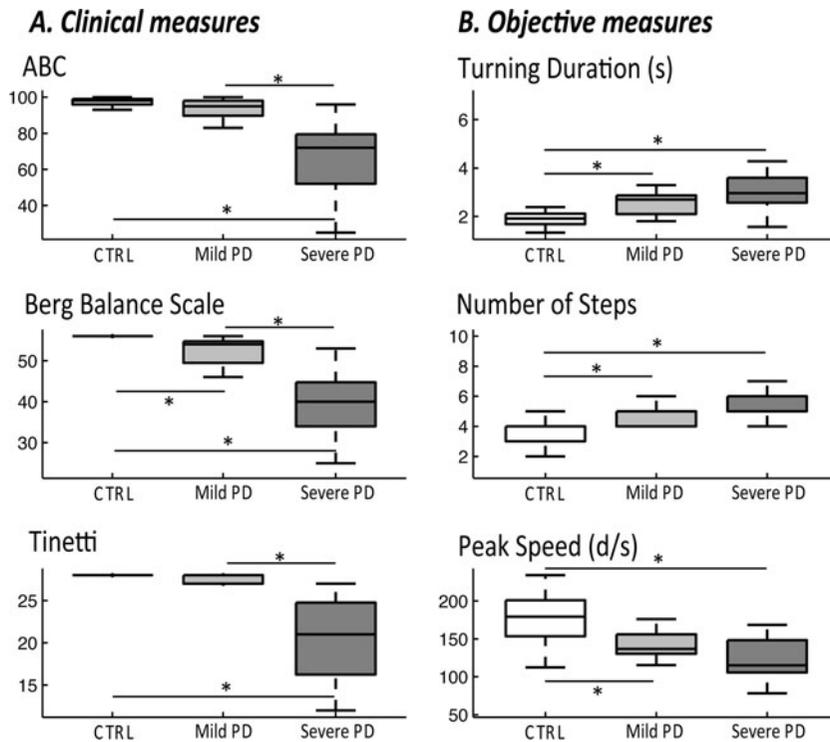


Figure 1. Box-plots comparing groups, instrumented turning measures, and clinical measures. Boxes indicate the interquartile range, middle lines the median, and whiskers the minimum-maximum values.

PD, and 3.2 (0.24) seconds for those with severe PD. The turning duration was significantly different among groups ($\chi^2 = 43.6$, $P < 0.0001$). In particular, post hoc testing revealed a significant increase in turning duration in people with mild or severe PD compared with control participants ($P = 0.00014$ and $P < 0.00001$, respectively). However, participants with mild versus severe PD did not show significantly different turning durations ($P = 0.03$).

The mean (SD) number of steps was 3.7 (0.2) steps for control participants, 4.5 (0.1) steps for participants with mild PD, and 5.6 (0.3) steps for those with severe PD. The number of steps to complete the turn was significantly different among all groups ($\chi^2 = 32.1$; $P < 0.0001$). Post hoc testing revealed a significantly greater number of steps in participants with mild PD or severe PD compared with control participants ($P = 0.0009$ and $P < 0.00001$). In addition, severe PD participants had a slightly greater number of steps than the mild PD participants ($P = 0.0087$). The mean (SD) peak speed was 174.5 (5.9) m/s for control participants, 143.03(3.5) m/s for participants with mild PD, and 128.1 (8.4) m/s for those with severe PD. The peak speed during turning was significantly different among all groups ($\chi^2 = 31.9$; $P < 0.0001$). In particular, post hoc test revealed a significant increase in peak speed in people with mild PD or severe PD compared with control participants ($P = 0.0001$ and $P < 0.00001$). However, there was no significant difference found in peak turning speed between people with severe and mild PD ($P = 0.06$).

Clinical Measures

The Berg total scores (mean [SD]) for the control participants, participants with mild PD, and participants with severe PD were 55.6 (0.9), 52.1 (4.0), and 40.6 (1.7), respectively. The Berg showed significant differences among groups ($\chi^2 = 54.9$; $P < 0.001$) and was statistically able to detect differences in balance between those with mild PD and those without PD. Significant differences were found between controls and those with mild PD ($P = 0.0003$) as well as between participants with mild PD versus severe PD ($P = 0.00008$).

The Berg items that showed the most difference between control participants and those with mild PD were as follows: standing tandem, standing on one foot, turning to look behind, functional reach, alternating step test, and 360° turn. Specifically, 43% of people with mild PD scored less than normal on the tandem stance, 43% on the single limb stance, 39% on the task to look behind, 39% on the functional reach, 26% on the alternating step task, and 17% on the 360° turn. Conversely, only 0 to 10% of the controls showed any abnormality on the scoring for these 6 items. The other items on the Berg showed very little to no difference between control participants and those with mild PD. The people with mild PD did not have any difficulties on the remaining items on the Berg, for this reason the Berg total score remained in the normal range for those with mild PD.

The ABC scores for the control, mild PD, and severe PD participants were (mean [SD]) 97.5 (0.5), 91.9 (2.2), 67.6 (4.3), respectively. These scores showed significant differences

among groups ($\chi^2 = 44.0$; $P < 0.0001$). However, there was no difference in balance confidence between the control participants and the people with mild PD ($P = 0.01$), although there was a difference between participants with mild versus severe PD ($P = 0.00004$). The Tinetti scores for the control, mild PD, and severe PD participants were (mean [SD]) 28 (0.3), 27 (0.3), 20.7 (1.0), respectively. This scale showed significant differences among groups ($\chi^2 = 47.9$; $P < 0.001$). However, there was no difference between control participants and those with mild PD ($P = 0.02$), although there was a significant difference in Tinetti scores between participants with mild PD versus severe PD ($P < 0.00001$).

Correlations

Correlations between clinical measures of balance and instrumented measures of turning were moderate but significant. All clinical measures of balance correlated moderately with peak speed of turning: ABC ($\rho = 0.36$; $P = 0.02$), Berg ($\rho = 0.39$; $P = 0.007$), and Tinetti ($\rho = 0.41$; $P = 0.004$). All clinical scales except the ABC ($\rho = 0.22$; $P = 0.14$) correlated with the number of steps to turn: Berg ($\rho = 0.33$; $P = 0.02$) and Tinetti ($\rho = 0.41$; $P = 0.01$). Correlations between clinical scales and the entire turn duration in seconds were the weakest; ABC ($\rho = 0.23$, $P = 0.13$), Berg ($\rho = 0.31$; $P = 0.03$), and Tinetti ($\rho = 0.38$; $P = 0.01$). The subscore of the 6 most difficult items of the Berg was also moderately correlated with turning: peak turning speed ($\rho = 0.40$; $P = 0.005$), the number of steps to turn ($\rho = 0.40$; $P = 0.006$), and turn duration ($\rho = 0.34$; $P = 0.02$).

The total time (in seconds) of the iTUG test correlated more strongly with the instrumented measures of turning than with the clinical tests: turn duration ($\rho = 0.71$; $P = 0.000$), the number of steps to turn ($\rho = 0.61$; $P = 0.00001$); peak speed of turn ($\rho = 0.73$; $P = 0.00001$); Berg ($\rho = 0.48$; $P = 0.001$); Tinetti ($\rho = 0.53$; $P = 0.00001$); ABC ($\rho = 0.47$; $P = 0.00001$). Interestingly, turn duration did not correlate with disease severity as measured by the UPDRS (which does not include a turn as part of the test) while other measures of turning did; turn duration ($\rho = 0.24$; $P = 0.11$); number of steps to turn ($\rho = 0.37$; $P = 0.01$); peak turning speed ($\rho = 0.45$; $P = 0.002$). The clinical scales of balance correlated moderately and significantly with disease severity; ABC ($\rho = 0.64$; $P = 0.00001$), Berg ($\rho = 0.76$; $P = -0.00001$), Tinetti ($\rho = 0.71$; $P = 0.00001$).

DISCUSSION

The findings of this study confirm our earlier results on early-untreated people with PD, showing that turning deficits are present even in very mild PD.¹ In this study, we had a larger and more varied sample size and compared the instrumented data with common clinical tests of balance. Instrumented data showed that the total duration of a turn was longer, the peak turn speed was slower, and more steps were taken in participants with PD. Furthermore, these measures scaled with PD severity. On the basis of these findings, it is possible that physical therapists may be missing the early signs of turning deficits in people with mild PD by performing only standard clinical balance assessments, as these individuals may have clinical balance scores within normal limits but exhibit abnormal turning

when quantified using instrumented measures. Since severe turning deficits relate to freezing episodes and falls, documenting and addressing early signs of turning deficits could be an important goal for physical therapists.

Even though the turning parameters were found to be different between the control subjects and those with mild PD, the ABC and Tinetti tests showed no difference in total score between these groups. The Berg, however, was capable of differentiating among the control, mild PD, and severe PD groups. These results were somewhat surprising since the Berg has been found to have a ceiling effect.²⁷ The difference between the groups on the Berg was small (4 points) and therefore it is important to consider the clinical relevance of that discrepancy.

Although controversial in the literature (and somewhat misguided on the basis of the original intent of the Berg^{28,29}), many clinicians continue to use a cutoff score of less than 45 as indicative of people at risk for falls. A person at risk for falls is more likely to receive physical therapy intervention or a falls-prevention program. However, with the exception of 2 participants, all the people in our mild PD group were well above the Berg cutoff score of 45, but nonetheless had signs of compromised turning strategies. Clinicians are accustomed to using the total Berg score to identify balance deficits and determine a treatment plan. Therefore, clinicians may decide that this group of persons with mild PD do not have measurable balance deficits, are not at risk for falls, and therefore would not be able to justify ongoing therapy to address balance deficits.

It has been suggested by others that the use of cutoff scores is not helpful in a disease such as PD that affects the postural control system in persons who are younger than those for whom the Berg was designed.²⁸ The results from this study are further evidence that such cutoff scores are not helpful in this population. Our results suggest that physical therapists should pay attention to particular items in the Berg that assess constructs of axial mobility, rotation, and dynamic changes in the base of support, as they may reflect difficulty with turns. These items should be factored into a clinical decision, beyond using only the total Berg score to document balance. It is important to consider that in this study we used a clinical scale to designate mild PD versus severe PD, and this may account for less than significant differences between the mild and severe groups in our instrumented measures. The H&Y and UPDRS, most often used to designate disease severity, do not include a turn as part of the test.

Our results may suggest that the clinical version of the TUG test may be a good test to use for people with PD, but close attention should be paid to the turning aspect of the test. The results here appear not to be consistent with those of our earlier study of 12 participants, in which the stopwatch TUG time did not show a difference between early, untreated people with PD and control participants.¹ One reason may be that the participants with mild PD in the current study were already on levodopa therapy, indicating a more impaired population than our previous study. Levodopa has also been shown to worsen balance deficits in PD.^{30,31} Other differences between the current and previous studies were that the total duration of the TUG task was obtained from the sensors rather than from a stopwatch and the iTUG has a longer walking distance. The

time derived from a stopwatch may be more inaccurate and variable than an instrumented time,³² and it is possible that the longer walking distance increased the consistency of the iTUG data.

How can a person with mild PD have slower turns, even when their gait is of normal speed and their clinical balance scores fall within normal limits? It has been suggested that turning-related neural systems may be more vulnerable to functional impairments than straight ahead linear gait since turning involves more interlimb coordination, more coupling between posture and gait, and modification of locomotor patterns requiring frontal lobe cognitive and executive function that plays a role in postural transitions.¹⁴ This complex nature of turning may explain why turning peak speed but not turn duration was significantly correlated with the UPDRS. Peak speed may be reflective of bradykinesia (which is measured in the UPDRS), while turn duration may measure other complex components that go into turning which are not measured by the UPDRS. Rehabilitation techniques, such as cueing, can be effective in increasing the speed of turns in people with PD, but it is unknown whether cueing or practicing turning can improve mobility. It is important for therapists to consider the underlying constraints involved in difficulty turning, such as inability to move the center of mass appropriately, rather than just counting steps or measuring turn duration and trying to directly reduce them.

Limitations

A limitation of the study is that we did not test the traditional 3-m TUG but used the extended 7-m version for the instrumented iTUG testing. Therefore, while the 7-m iTUG total time showed differences between groups, it is unclear whether the traditional, shorter TUG would show similar results because of less time walking. Another limitation of this study is that we did not assess turning in both directions, nor did we assess turns of varying magnitudes. We measured the preferred direction of turning during the iTUG, which may not reflect participants' most impaired performance. Other groups have shown that there is an asymmetry in turning for people with PD and people with PD have difficulty turning at varying magnitudes⁷ as well as turning under a sudden cued situation requiring quick movements.³³ Future studies using quantitative measures should consider turn direction, size, and environmental constraints, such as turning in crowded spaces. Finally, while this study assessed overall balance scales, we did not assess a turn-specific clinical evaluation on its own since there are no currently agreed-upon ways in which to assess turning for persons with neurologic conditions (ie, stopwatch, count the number of steps; independent of a general balance scale is not common practice). We tested the assumption that a deficit in this particular area of mobility would be detected in overall balance assessments.

CONCLUSIONS

We show evidence that turning is impaired, even in mildly impaired participants with PD, and that this deficit is not obviously reflected in common clinical scales of balance such as the Berg or Tinetti. Scores on clinical scales were correlated with instrumented turn metrics, but the correlations were

low-to-moderate, suggesting that separate turning evaluations should be performed, even in persons with mild PD or normal Berg scores. It may be more useful for a clinician to examine particular items within the Berg or the turning component of the TUG if turning difficulty is suspected. Early intervention and fall prevention are paramount to health and function, so it is critical that early signs of mobility deficits are not overlooked. Recently, attention has been focused on early intervention and exercise as an effective means to prevent mobility disability in PD.³⁴ Efficacy studies are needed on PT interventions for difficulty turning³⁵ and the value of this type of intervention for decreasing fall risk.

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Effects of a High Intensity Resistance Training Program on Strength, Mobility, Balance and Fatigue in Individuals with Multiple Sclerosis: A Randomized Controlled Trial

By Heather A. Hayes, Eduard Gappmaier, and Paul C. LaStayo

The article was published in the March 2011 issue of JNPT (Volume 35, Number 1, pp. 2-10).

The authors were recognized with award plaques at the Neurology Section Business Meeting in Chicago, IL.