The Primary Gait Screen in Parkinson's disease: Comparison to standardized measures

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ABSTRACT

Background: Persons with Parkinson's disease exhibit gait deficits during comfortable-pace overground walking and data from pressure sensitive mats have been used to quantify gait performance. The Primary Gait Screen is a new assessment which includes gait initiation, overground walking, turning, and gait termination. Although overground assessments are useful, the Primary Gait Screen offers a more complex evaluation than traditional gait assessments.
Research question: Is the overground walking portion of the Primary Gait Screen comparable to traditional gait assessments?
Methods: Persons with Parkinson's disease (N = 175; 47 F, 128 M; 67 ± 9 yrs) prospectively completed 4 passes at a self-selected speed and two trials of the Primary Gait Screen on an 8 m long pressure-sensing mat. Spatiotemporal gait variables were computed and a repeated-measures MANOVA with a Bonferroni correction compared the spatiotemporal variables from the Primary Gait Screen to the self-selected trials: gait velocity, cadence, step length, step time, and stride length.
Results: The analyses failed to detect differences between the Primary Gait Screen and self-selected trials for gait velocity, step length, or stride length (p > .01). Post-hoc tests revealed decreased cadence and increased step time were the only differences between the Primary Gait Screen trials and the self-selected trial (p < .001).
Significance: Differences seen in cadence and step time during the Primary Gait Screen may be attributed to patients' strategy, but are likely not clinically meaningful. The Primary Gait Screen appears to be a comparable assessment of overground walking in persons with Parkinson's disease, and may be a useful and accurate clinical assessment of walking.

1. Introduction

Persons with Parkinson's disease (PD) report that gait impairments are among the most disabling symptoms [1–4], and as a result, gait performance has received considerable attention in the clinical and biomechanics literature [4–10]. Many persons with PD exhibit deficits during comfortable-pace overground walking, including decreased gait velocity and stride length and increased time spent in double support [4,6,7,9]. While gait speed is often considered the best overall clinical metric for assessing movement, these other spatiotemporal variables are commonly used to classify the level of gait impairment [7,11]. A considerable amount of literature has relied on data derived from pressure-sensing mats that capture gait performance as participants

walk at their comfortable self-selected (SS) pace over the mat [6,7,9,12].

Of note, these quantitative clinical gait assessments are often unable to quantify more complex behaviors necessary to complete activities of daily living or to maintain independence. Community ambulation requires the ability to manipulate speed, specifically to initiate and terminate walking and coordinate turning. Persons with PD have been shown to exhibit deficits with these complex walking tasks, thus more comprehensive assessments are necessary [9,13]. With recent technological advancements, pressure-sensing mats have the capacity to measure performance during more complex activities. The Primary Gait Screen (PGS) is a new rapid assessment protocol, developed by Proto-Kinetics (Havertown, PA), which incorporates gait initiation, SS
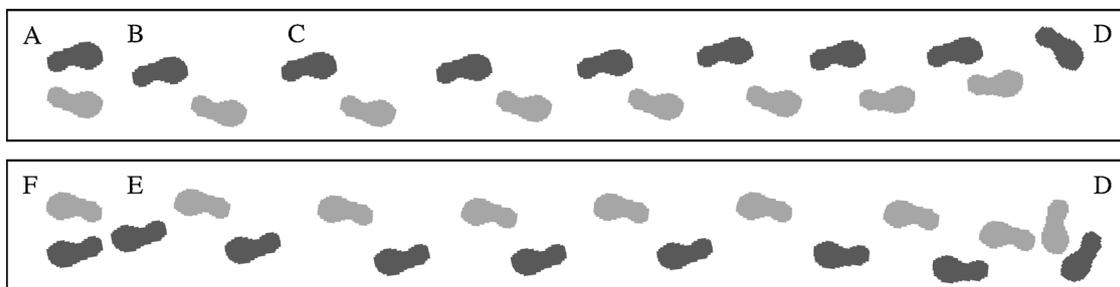
Fig. 1. Schematic of the Primary Gait Screen (PGS). During the PGS, patients are asked to balance for 10 s (A) and initiate gait (B) following an auditory cue (a beep). They are asked to walk at a self-selected pace (C) to the end of the walkway and turn around (D) and walk back to the beginning of the walkway where they should terminate gait (E) and balance for an additional 10 s (F).

walking, turning, and gait termination into the standard overground assessment using the same available space and pressure-sensing mat (Fig. 1). PGS may be a useful assessment to readily capture more comprehensive movement data in a brief time period. To date, there are no published reports assessing the utility of the PGS. The PGS was designed for clinical gait assessments. Therefore, considering the deficits in forward walking and transitional movements in persons with PD, we believe this is an ideal population to assess the utility of the PGS. Thus, we focused this work on confirming whether the assessment of gait captured during performance of the PGS is comparable to the traditional SS protocol in persons with PD.

2. Methods

Overground gait was assessed in 175 adults diagnosed with idiopathic PD (47 F, 128 M; Table 1). Participants were able to walk without the use of an assistive device, safely complete both the PGS and SS assessments, and did not freeze during any of the trials. Participants completed a standard protocol on an 8 m Zeno Walkway (120 Hz, ZenoMetrics, Peekskill, NY) including 4 passes over the mat at a self-selected speed and two trials of the PGS, resulting in a total of 4 passes over the mat during the PGS. During the SS trial, participants started 1 m before the walkway and turned 1 m after the end of the walkway [14]. Further, the first and last 0.6 m of the SS trials were excluded to eliminate the first and last steps on the mat for accommodation purposes (i.e., remove any acceleration and deceleration effects on the steady-state performance).

Spatiotemporal variables were computed from the SS walking portion of the PGS trials using custom MATLAB software (2016a, Mathworks Inc., Natick, MA). PGS trials were processed independently and the resulting spatiotemporal variables and gait velocities from the two trials were averaged. The calculations were based on those of Huxham et al. [15] consistent with the ProtoKinetics Movement Analysis Software (PKMAS) (version 509.c1, ProtoKinetics). Data from the gait initiation, termination, and turning portions of the PGS were excluded; only the steady-state walking was used (Fig. 1C). A repeated-measures MANOVA was used to compare the following spatiotemporal variables from the PGS to the SS trials: gait velocity, cadence, step length, step time, and stride length. If multivariate tests resulted in significant differences, univariate comparisons with Bonferroni corrections were used to identify where differences occurred ($p < .01$).

The PGS protocol within PKMAS automatically calculates a velocity for the gait portion of the PGS. In a separate analysis, we used PKMAS to alter the processing settings of the PGS trials to investigate the influence of settings on calculated gait velocity. In an effort to preserve clinical applicability, the gait velocity data from the PGS trials were processed 3 times using 3 different cutoffs (excluding the first and last 1 m, 1.5 m, 2 m of the walkway). Specifically, during the 1 m cutoff processing, the data from the first and last meter of the walkway were ignored in the computation of gait velocity. Similarly, during the 1.5 m and 2 m cutoff processing, the first and last 1.5 m or 2 m were ignored resulting in a velocity calculated from the middle 5 m or 4 m of the mat. This was done to avoid biasing the gait velocity calculations with the initiation, turn, and termination portions of the PGS and to allow for recommendations for clinical assessments in clinics where an 8 m instrumented mat is not feasible or affordable. Consistent with the first analysis, PGS trials were independently processed and resulting gait velocities from the two trials were averaged. A repeated-measures ANOVA with Bonferroni corrections was used to compare the gait velocities from the different PGS cutoffs to the SS trial ($p < .05$). Cohen's d was calculated to estimate effect size using .2 as small effect, .5 as a medium effect, and .8 as a large effect. As the small important difference for gait velocity in persons with PD has been defined as 0.06 m/s, this was used to define a meaningful difference [6].

3. Results

Multivariate tests revealed significant differences in spatiotemporal measures between the SS trial and the SS portion of the PGS trials ($\Lambda^* = .260$, $F(5,170) = 96.659$, $p < .001$). Follow-up univariate tests revealed decreased cadence and increased step time during the PGS trials compared to the SS trial ($p < .001$). No differences were found between the PGS and SS trials for gait velocity, step length, or stride length ($p > .01$). See Table 2.

Despite a significant univariate result ($p < .05$), with Bonferroni corrections, there were no significant, meaningful differences found between the SS and the computed PGS gait velocities (1m: t (174) = 2.311, $p = .132$, Cohen's d = 0.075; 1.5 m: t(174) = −0.423, $p = .673$, Cohen's d = 0.013; 2 m: t(174) = −1.528, $p = .128$, Cohen's d = 0.048). The resulting average gait velocities using the 1m, 1.5 m, and 2 m cutoff were 1.12 m/s, 1.14 m/s, and 1.14 m/s, respectively,

Table 1
Participant Demographics ($n = 175$).

	Mean ± SD
Sex	128 M/47 F
Age (years)	67 ± 9
Hoehn & Yahr Score	2.0 ± 0.6
UPDRS Part III Motor Score	22.6 ± 8.8
Disease Duration (years)	10.5 ± 7.1

Table 2
Spatiotemporal parameters between the 4x Self-Selected (SS) walking trials and the Primary Gait Screen (PGS). **Bolded** values indicate significance.

	SS trial	PGS trial	*P*-value	Cohen's d
Gait Velocity (m/s)	1.13 ± 0.18	1.14 ± 0.19	.248	0.05
Cadence (steps/min)	106.8 ± 9.1	105.3 ± 9.0	**.000**	0.17
Step Length (m)	0.63 ± 0.09	0.63 ± 0.09	.202	0.0
Step Time (s)	0.56 ± 0.05	0.57 ± 0.05	**.000**	0.2
Stride Length (m)	1.27 ± 0.18	1.26 ± 0.17	.640	0.05

while the gait velocity from the SS trial was 1.13 m/s.

4. Discussion

The primary goal of this study was to determine if spatiotemporal parameters calculated during the PGS are comparable to values generated by walking uninterrupted across the mat. The lack of differences between assessments for a majority of the variables suggest the walking portion of the PGS is comparable to the assessment of traditional walking trials. Small differences in cadence and step time were observed during the PGS trials, potentially as a result of the parameters of the task. Although the gait initiation and turn portions of the task are excluded from this analysis, patients appear to take slower steps leading to decreased cadence during the PGS when compared to the uninterrupted walking trial, perhaps in anticipation of the transitional movements. These differences may be attributed to the strategy the patients used to complete the task but are likely not clinically meaningful.

The secondary goal of this study was to alter processing parameters to evaluate the settings to calculate gait velocity using the PGS protocol within PKMAS. No significant differences were observed between the processed PGS trials and the gait velocity measured during the SS walking trial. The greatest mean difference in gait velocity between the PGS and SS was 0.01 m/s (1 m cutoff), which does not surpass the minimally important difference for gait velocity in this population [6]. This data suggests that 1 m is adequate room on either end of the mat to accommodate the gait initiation/termination and turning portions of the PGS without biasing the SS portion of the PGS. Clinicians and researchers should take into account this additional 2 m necessary for performing the PGS when selecting a walkway of sufficient length to evaluate SS walking.

Based on this information, the PGS is a comparable assessment of overground walking in persons with PD, even on shorter pressure mats with minimal gait data lost to the gait initiation/termination and turning portions of the PGS. Collectively, these results suggest the PGS may be a useful and accurate clinical assessment of walking in persons with PD and has potential for use with other clinical populations.

CRediT authorship contribution statement

Abigail C. Schmitt: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Writing - original draft, Writing - review & editing. **Justin N. Daniels:** Software, Validation, Investigation, Writing - review & editing. **Sidney T. Baudendistel:** Investigation, Formal analysis, Writing - review & editing. **Michael S. Okun:** Resources, Writing - review & editing. **Chris J. Hass:** Conceptualization, Methodology, Writing - original draft, Writing - review & editing, Supervision.

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References

[1] A. Hassan, S.S. Wu, P. Schmidt, I.A. Malaty, Y.F. Dai, J.M. Miyasaki, et al., What are the issues facing Parkinson's disease patients at ten years of disease and beyond? Data from the NPF-QII study, Parkinsonism Relat. Disord. 18 (Suppl. 3) (2012) S10–14 http://www.ncbi.nlm.nih.gov/pubmed/22776044.

[2] A.N. Nisenzon, M.E. Robinson, D. Bowers, E. Banou, I. Malaty, M.S. Okun, Measurement of patient-centered outcomes in Parkinson's disease: what do patients really want from their treatment? Parkinsonism Relat. Disord. 17 (2) (2011) 89–94 http://www.ncbi.nlm.nih.gov/pubmed/20952243.

[3] A.H. Snijders, B.P. van de Warrenburg, N. Giladi, B.R. Bloem, Neurological gait disorders in elderly people: clinical approach and classification, Lancet Neurol. 6 (1) (2007) 63–74 https://www.ncbi.nlm.nih.gov/pubmed/17166803.

[4] G. Ebersbach, C. Moreau, F. Gandor, L. Defebvre, D. Devos, Clinical syndromes: Parkinsonian gait, Mov. Disord. 28 (11) (2013) 1552–1559 https://www.ncbi.nlm.nih.gov/pubmed/24132843.

[5] T.A. Boonstra, H. van der Kooij, M. Munneke, B.R. Bloem, Gait disorders and balance disturbances in Parkinson's disease: clinical update and pathophysiology, Curr. Opin. Neurol. 21 (4) (2008) 461–471 http://www.ncbi.nlm.nih.gov/pubmed/18607208.

[6] C.J. Hass, M. Bishop, M. Moscovich, E.L. Stegemoller, J. Skinner, I.A. Malaty, et al., Defining the clinically meaningful difference in gait speed in persons with Parkinson disease, J. Neurol. Phys. Ther. 38 (4) (2014) 233–238 https://www.ncbi.nlm.nih.gov/pubmed/25198866.

[7] C.J. Hass, P. Malczak, J. Nocera, E.L. Stegemoller, A. Wagle Shukla, I. Malaty, et al., Quantitative normative gait data in a large cohort of ambulatory persons with Parkinson's disease, PLoS One 7 (8) (2012) e42337 http://www.ncbi.nlm.nih.gov/pubmed/22879945.

[8] R.T. Roemmich, A.M. Field, J.M. Elrod, E.L. Stegemoller, M.S. Okun, C.J. Hass, Interlimb coordination is impaired during walking in persons with Parkinson's disease, Clin. Biomech. (Bristol, Avon) 28 (1) (2013) 93–97 http://www.ncbi.nlm.nih.gov/pubmed/23062816.

[9] R.T. Roemmich, J.R. Nocera, S. Vallabhajosula, S. Amano, K.M. Naugle, E.L. Stegemoller, et al., Spatiotemporal variability during gait initiation in Parkinson's disease, Gait Posture 36 (3) (2012) 340–343 http://www.ncbi.nlm.nih.gov/pubmed/22543093.

[10] E.L. Stegemoller, T.A. Buckley, C. Pitsikoulis, E. Barthelemy, R. Roemmich, C.J. Hass, Postural instability and gait impairment during obstacle crossing in Parkinson's disease, Arch. Phys. Med. Rehabil. 93 (4) (2012) 703–709 http://www.ncbi.nlm.nih.gov/pubmed/22318131.

[11] S. Fritz, M. Lusardi, White paper: "walking speed: the sixth vital sign", J. Geriatr. Phys. Ther. 32 (2) (2009) 46–49 http://www.ncbi.nlm.nih.gov/pubmed/20039582.

[12] B.R. Bloem, J. Marinus, Q. Almeida, L. Dibble, A. Nieuwboer, B. Post, et al., Measurement instruments to assess posture, gait, and balance in Parkinson's disease: critique and recommendations, Mov. Disord. 31 (9) (2016) 1342–1355 http://www.ncbi.nlm.nih.gov/pubmed/26945525.

[13] M. Morris, F. Huxham, J. McGinley, K. Dodd, R. Iansek, The biomechanics and motor control of gait in Parkinson disease, Clin. Biomech. 16 (2001) 459–470 https://www.ncbi.nlm.nih.gov/pubmed/11427288.

[14] Y. Laufer, Effect of age on characteristics of forward and backward gait at preferred and accelerated walking speed, J. Gerontol. A Biol. Sci. Med. Sci. 60 (5) (2005) 627–632 https://www.ncbi.nlm.nih.gov/pubmed/15972616.

[15] F. Huxham, J. Gong, R. Baker, M. Morris, R. Iansek, Defining spatial parameters for non-linear walking, Gait Posture 23 (2) (2006) 159–163 https://www.ncbi.nlm.nih.gov/pubmed/16399511.