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Assistive devices alter gait patterns in Parkinson disease: Advantages of the four-wheeled walker

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ABSTRACT

Gait abnormalities are a hallmark of Parkinson's disease (PD) and contribute to fall risk. Therapy and exercise are often encouraged to increase mobility and decrease falls. As disease symptoms progress, assistive devices are often prescribed. There are no guidelines for choosing appropriate ambulatory devices. This unique study systematically examined the impact of a broad range of assistive devices on gait measures during walking in both a straight path and around obstacles in individuals with PD. Quantitative gait measures, including velocity, stride length, percent swing and double support time, and coefficients of variation were assessed in 27 individuals with PD with or without one of six different devices including canes, standard and wheeled walkers (two, four or U-Step). Data were collected using the GAITRite and on a figure-of-eight course. All devices, with the exception of four-wheeled and U-Step walkers significantly decreased gait velocity. The four-wheeled walker resulted in less variability in gait measures and had less impact on spontaneous unassisted gait patterns. The U-Step walker exhibited the highest variability across all parameters followed by the two-wheeled and standard walkers. Higher variability has been correlated with increased falls. Though subjects performed better on a figure-of-eight course using either the four-wheeled or the U-Step walker, the four-wheeled walker resulted in the most consistent improvement in overall gait variables. Laser light use on a U-Step walker did not improve gait measures or safety in figure-of-eight compared to other devices. Of the devices tested, the four-wheeled-walker offered the most consistent advantages for improving mobility and safety.

1. Introduction

Gait and balance problems in individuals with PD cause frequent falls [1]. Falls typically occur while a person is turning, initiating gait, and sitting down [1]. Fractures from falls are higher in patients with PD compared with age-matched controls [2,3]. Thus, fall prevention is important for PD clinical management.

As PD symptoms progress, clinicians may prescribe assistive devices (ADs). Typically canes are prescribed for mild and walkers for more severe gait problems. In individuals with PD, use of a cane, standard or four-wheeled walker has been found to significantly reduce walking speed [4,5] and standard walker use induced more freezing of gait (FOG) when compared to unassisted walking [4]. Four-wheeled walker use significantly reduced stride length, while other gait parameters (i.e. cadence, double support percent, heel-to-heel base of support, stride and stance times) were unaffected by usage of assistive device compared to walking without a device [5]. To overcome FOG and/or improve step length, ADs with lasers that project a light to step over are prescribed. One study [4] found no reduction in FOG with laser attached to a four-wheeled walker while another reported a modest decrease in freezing with laser attached devices. People with PD may be more likely to abandon use of an AD if it causes reduced speed [6,7]. Knowledge of the potential effects of ADs on gait measures in PD may improve prescription practices and patient compliance.

Previous studies that investigated gait changes with assistive device use in people with PD utilized only a limited number of devices and did not investigate gait variability or walking around obstacles which could increase fall risk [4,5]. Therefore the purpose of this study was to compare spatiotemporal gait measures in individuals with PD while using a wide variety of commonly prescribed ADs during both walking in a straight path and maneuvering around obstacles. Based on previous findings in PD [4], and other patient populations [8–12], we hypothesized that spatiotemporal gait measures and variability would be: (1)

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different when participants ambulated with an AD compared to without; (2) improved when participants ambulated with swivel-wheeled walkers (i.e. four-wheeled or U-Step walkers) compared to walkers without; and (3) improved with laser light use. We also hypothesized that gait speed would be improved and there would be fewer balance losses and FOG episodes during turns when participants used swivel-wheeled walkers compared to devices without swivel wheels. Identification of effective ADs will enable clinicians to make more appropriate AD prescriptions for individuals with PD.

2. Methods

Participants were volunteers recruited via written and verbal communication from individuals who attended our clinic and/or a community exercise class and were consented in to the study. A target recruitment number of 30 was set a priori; all volunteers met inclusion criteria but only 27 individuals entered the study. Inclusion criteria were a diagnosis of PD confirmed by a neurologist; age >50; ability to walk a minimum of 10 m without an AD or assistance; absence of any additional central nervous system disorders; and absence of orthopedic and peripheral neurological disorders affecting the lower extremities. Since individuals with PD have abnormal gait patterns compared to healthy individuals, participants were used as their own controls with the no AD condition as the comparison or baseline condition. The study was approved by the University Institutional Review Board.

Spatiotemporal gait measures were collected using the GAITRite System® (CIR systems), The GAITRite measures are valid and reliable in people with PD [13]. An aluminum straight cane (cane) (Harvey Surgical Supply Corporation), a standard walker (StW) (Graham-Field Health Products), a two-wheeled walker (2WW) with fixed wheels (Medline Industries), a four-wheeled walker (4WW) with front swivel casters (Invacare Corporation) and a U-Step walker (UstW) with six swivel wheels and a laser (In-Step Mobility Products) were utilized. All ADs were adjusted to fit each participant.

The Unified Parkinson Disease Rating Scale (UPDRS) motor scale [14] was administered by an investigator (DK) and demographic data including age, sex, and number of years since symptom onset was obtained. Participants reported any falls in the past 6 months. Data were normalized to each person's height.

Prior to testing, a therapist trained each participant on an AD. Training time was individualized until the participant demonstrated correct and safe device use as determined by observation of a smooth, continuous forward progression with gaze directed forward and without loss of balance. During walking trials with the UstW, the laser was turned on at all times and participants were told to step over the light beam but not to use the light beam for every step in order to maintain a forward gaze. Training time was generally equivalent to time typically spent in our clinic to teach device use. Participants then walked at a normal, comfortable pace across the GAITRite carpet for four trials under each of the conditions. The first trial was a practice trial. The GAITRite software averaged the data from the remaining three trials for each condition. Participants began walking 2 m before and stopped 2 m beyond the carpet edges to allow for acceleration and deceleration. Participants wore a gait belt and were guarded at all times during testing.

To test maneuverability around obstacles, participants were timed while they walked as fast as they could in a figure-of-eight pattern around two chairs set 4 feet apart under all six conditions. Each participant performed the course twice; the time to complete the second trial was recorded. Investigators also recorded the number of freezing episodes (completely stopped then resumed walking), number of stumbles (loss of balance with unassisted recovery), and falls (loss of balance with assistance for recovery). Device use order was randomized and participants could rest whenever necessary.

Coefficient of variation (CV) values were calculated to assess the variability of gait measures across devices. For CV, the average time series of steps across three walkway trials was utilized to calculate the mean and standard deviation. Data for each of the gait measures and CVs were normally distributed and were analyzed using one-way repeated-measures ANOVA to detect differences between the different walking conditions. Tukey post hoc testing was used to adjust for multiple comparisons and to control the type I error rate at .05. Significance was set a priori at <.05. All statistical analysis was performed using SAS Version 9.2.

3. Results

Participants' (27) average age was 69.7 ± 1.3 years old (range 55–83 years), and they were 8.3 ± 7.1 years post diagnosis (range <1–30 years) with UPDRS motor scores of 24.2 ± 2 (range 9–44). There were more men (22) than women (five). Fourteen of the 27 participants (52%) reported falls in the last 6 months. All participants reported being at optimal drug effect (i.e. "on" time) during the testing session. No participants regularly utilized an AD, although a few reported having used an AD in the past. All participants exhibited gait and balance deficits on the UPDRS and GAITRite.

3.1. Gait measures across ADs

In comparison to the no AD condition (baseline), walking velocity with the 4WW was statistically equivalent while all other ADs produced significantly ($p < .05$) decreased mean velocity (Table 1). Analysis of differences between gait parameters across ADs showed that walking with the 4WW produced a gait pattern that was most similar to the no AD condition with respect to higher velocity (1.01 ± .04 m/s), longer stride length (118.6 ± 3.9 cm), and more of the gait cycle spent in swing (37.2 ± .40%) and less in double support (26.6 ± .73%) (Table 1). The cane produced a gait pattern much like the no AD and 4WW conditions but with significantly slower velocity (.94 ± .05 m/s) as compared to no AD (1.08 ± .04 m/s). Standard walker use produced the lowest velocity (.63 ± .05 m/s) and shortest stride length (96.6 ± 5.5 cm) of all devices ($p < .05$). The 2WW also produced a slow (.80 ± 5.3 m/s) gait compared to all other conditions ($p < .05$) with shorter stride lengths (93.1 ± 5.5 cm) while the UstW produced a gait with prolonged time in double support (50.5 ± 2.9%) and less time in the swing phase of gait (27.0 ± 1.7%) as compared to all other conditions ($p < .05$). The narrowest base of support was achieved with the UstW (7.7 ± 4.2 cm; $p < .05$).

Table 1
Gait measures across all walking conditions: mean (standard error).

	No AD	Cane	Standard walker	Two wheel walker	Four wheel walker	U Step walker
Velocity (m/s)	1.08	.94[*,#,+]	.63[**]	.80[**]	1.01[#,+]	.96[*,#,+]
	(.04)	(.05)	(.05)	(.05)	(.04)	(.05)
Stride length (cm)	119.9	117.1[#,+]	96.6[*,§]	93.1[*,§]	118.6[#,+]	121.2[#,+]
	(4.5)	(4.3)	(5.5)	(5.8)	(3.9)	(4.9)
Swing	37.5	36.6[†]	34.5[†]	34.0[†]	37.2[†]	27.0[**]
%gait cycle	(.43)	(.51)	(1.1)	(.97)	(.40)	(1.7)
Double support	26.3	29.1[†]	34.1[*,†]	33.6[†]	26.6[†]	50.5[**]
%gait cycle	(.71)	(1.6)	(2.0)	(2.6)	(.73)	(2.9)
Base of support (cm)	9.8	9.6[†]	9.3	9.8[†]	8.9	7.7[*,♌]
	(3.2)	(3.0)	(6.4)	(2.2)	(2.3)	(4.2)

Abbreviation: CV, coefficient of variation.
[*] Significantly different than no AD at $p < .05$.
[**] Significantly different than all other conditions at $p < .05$.
[#] Significantly different than StW at $p < .05$.
[+] Significantly different than 2WW at $p < .05$.
[†] Significantly different than UstW at $p < .05$.
♌ significantly different than cane, 2WW at $p < .05$.
[§] Significantly different than cane, 4WW, Ust at $p < .05$.