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RESEARCH ARTICLE

Gait changes with walking devices in persons with Parkinson's disease

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Purpose: **To study immediate gait changes in persons with PD when walking with different assistive walking devices.** ***Methods:*** **Ten individuals with idiopathic PD participated in the study. Gait parameters were recorded while walking with a cane and a wheeled walker, and were compared to a free walk without a walking device.** ***Results:*** **Persons with PD walked with slower gait speed when using a cane and a wheeled walker compared to walking without any device ($p = 0.007$, $p = 0.002$, respectively). Stride length reduced significantly when walking with a wheeled walker ($p = 0.001$). Walking with the assistive devices did not affect cadence, double support phase, heel to heel base of support, stride time, and stance period.** ***Conclusion:*** **Persons with PD immediately walked with slower gait speed when using either a cane or a wheeled walker, and with shorter stride length when walking with a wheeled walker. The results may lead to more cautious clinical practice in gait rehabilitation using ambulatory assisted devices.**

Keywords: Parkinson's disease, gait, assistive devices, rehabilitation

Implications for Rehabilitation

- Persons with PD immediately walked with slower gait speed when using either a cane or a wheeled walker, and with shorter stride length when walking with a wheeled walker.
- Clinicians should be cognizant of these modifications during gait rehabilitation using ambulatory assisted devices.

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Introduction

Balance and gait disturbances are major problems in individuals with Parkinson's disease (PD) and are major causes of falls in this population. Medical treatment provides symptomatic relief but does not affect the progression of PD. In most cases, these deficits increase as the disease progresses and disability eventually develops. The management of patients with PD is formidable and lifelong. Therefore, assistive ambulatory devices are the main form of adjunctive treatment for most individuals with gait and stability problems so that they can move about independently and maintain their independence longer [1, 2].

Walking devices such as canes and walkers are frequently prescribed for older adults with limited mobility. Nearly 5 million older adults reported that they used walking aids; 155,000 used crutches, 3,150,000 used canes, and 1,398,000 used walkers [3]. Canes generally are prescribed for people with moderate levels of mobility impairment, and walkers are prescribed for people with generalized weakness, poor lower-limb weight-bearing, debilitating conditions, or poor balance control [4]. For persons with PD, wheeled walkers should be favored because they do not aggravate freezing. In addition, they are easy to manipulate and do not require stopping and lifting the walker forward [5]. A pick-up walker can potentially have a destabilizing effect in persons with PD due to a lifting burden [6], thus increasing risk of falls.

There is very little information available in the literature on how persons with PD modify their gait characteristics when using different assistive ambulatory devices. We conducted this study to demonstrate the actual influence of assistive devices on gait in patients with PD without additional training provided by a clinician. A previous study reported that only 33 % of cane users received professional assistance when selecting an ambulatory device, which can lead to an inappropriate selection and use [7]. This infers that majority of the device users do not receive advice or gait training. An understanding of the gait changes with the assisted ambulatory devices will provide insights into how clinicians should provide additional gait training in using the devices effectively and properly. The aim of this study was to investigate the immediate gait modifications in persons with PD when using a cane and a wheeled walker.

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Methods

Subjects

Ten males with idiopathic PD participated in the study. All participants received anti-parkinsonian medications and reported having either gait or balance impaired from PD; however, they usually ambulated independently without any walking device. None of the subjects had a history of cognitive impairment.

Procedures

Each subject received an explanation of all procedures and read and signed a consent form approved by the Institutional Review Board. A brief medical history, demographic information (gender, age, height, and weight), disease duration, disability stage [8], and the Unified Parkinson Disease Rating Scale (UPDRS) motor score were obtained [9]. All subjects had impairment of balance, which was rated as at least 1 (retropulsion, but recovers unaided) on the item 30 (postural stability) of the UPDRS [9].

Cane length and walker height were adjusted so that each subject's elbow was at approximately 30 degree flexion [10]. The following conditions were performed: (1) walking without any device; (2) walking with a cane; (3) walking with a wheeled walker. Subjects were instructed to walk at their self-selected speed with the devices on an electronic walkway (GAITRite) to record their gait parameters.

Subjects were allowed to practice walking a few steps with each assistive device prior to data collection to minimize hesitancy in maneuvering and to familiarize with the device. Only few steps were allowed to ensure that there were no gait characteristics changed from the practice effect. Gait data were recorded during one session with the subject first walking without an assistive device, then walking with a cane, and later walking with a wheeled walker. A research assistant walked alongside slightly behind the subjects to ensure safety. Rest periods were given between conditions to minimize any carry-over effects that might occur from repeated walking and to avoid fatigue.

Equipment and measures

The GAITRite system (GAITRite, CIR Systems Inc., Havertown, PA, USA), is a 5-m, instrumented walkway containing an array of sensor pads encapsulated in a roll-up carpet. While the subject walks, the system continuously detects foot pressure and transfers the information to the connected computer for calculating gait parameters [11]. Measurement of gait parameters are computed and stored on the computer system. Variables of interest were: gait speed, cadence, stride length, stride time, percentage of double support phase, heel to heel base of support, and stance percent (Appendix A).

Statistical analysis

All statistical analyses were performed using SPSS version 18.0. Demographic data were descriptively summarized. One-way repeated-measures analysis of variance (ANOVA) was used to assess the changes in gait parameters. *Post-hoc* comparisons with Bonferroni adjustment were performed to compare the gait parameters between each pair of the three walking conditions. Significant level was set at $p < 0.017$.

Results

Displayed in Table 1 are the characteristics of the subjects. Comparisons of gait characteristics of the three ambulation conditions are shown in Table 2. The one-way repeated-measures ANOVA revealed a significant difference in the gait speed ($F = 8.57$, $p = 0.01$) and stride length ($F = 10.94$, $p = 0.005$) among the three conditions. The results of the *post-hoc*, pair-wise comparisons with Bonferroni adjustment indicated that persons with PD walked with slower gait speed when using a cane and when using a wheeled walker compared to walking without a device ($p = 0.007$, $p = 0.002$, respectively). Stride length reduced significantly when walking with a wheeled walker compared to a free walk without a device ($p = 0.001$). No significant differences were found in cadence, stride time, percentage of double support phase, heel to heel base of support and stance period when walking with a cane and a wheeled walker compared to walking without a device. No significant differences were found in all gait characteristics when walking with a cane compared to walking with a wheeled walker.

Discussion

We reported results from an investigation of the immediate effect of different walking devices on gait parameters in persons with PD. Currently, no quantitative data exist on the comparison of gait modifications during unassisted ambulation and during ambulation with a cane and a wheeled walker in the persons with PD.

The purpose of our study, therefore, was to quantify the gait modifications imposed immediately during assisted ambulation with a cane and a wheeled walker and to compare to unassisted walk in individuals with PD. We did not provide any professional instruction on how to use the walking device to prevent gait modification from the instruction. This allowed us to demonstrate gait modifications due to the assistive device alone, not from any clinician feedback or verbal corrections, which usually occur during supervised gait training.

Our results were in agreement with previous findings in elderly population. Walking speed was decreased during cane-assisted walking and during walking with a wheeled walker in healthy older adults aged between 50 to 74 years [12]. Our findings demonstrated that ambulation with a cane

Table 1. Subject characteristics ($N = 10$; males).

Subject characteristics	Mean ± SD
Age	68.70 ± 5.68
Height (cm)	179.94 ± 7.67
Weight (kg)	86.88 ± 14.66
BMI (kg/m^2)	26.88 ± 4.52
Years of PD	9.60 ± 4.62
H&Y	2.7 ± 0.48
UPDRS III	28.6 ± 10.01

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Table 2. Immediate gait changes with assistive ambulatory device.

Measures	Free walk	Cane walk	Wheeled walker walk	p Value[a]	p Value[b]	p Value[c]
Gait speed (cm/s)	100.60 ± 23.66	81.81 ± 25.64	85.82 ± 22.03	0.007	0.002	0.408
Cadence (steps/min)	105.82 ± 13.63	94.91 ± 18.89	100.97 ± 14.88	0.028	0.110	0.168
Stride Length (cm)	113.14 ± 14.63	102.96 ± 19.11	100.84 ± 16.94	0.048	0.001	0.582
Stride time (s)	1.17 ± 0.17	1.34 ± 0.22	1.22 ± 0.23	0.062	0.366	0.198
Double support (%GC)	24.45 ± 6.01	25.11 ± 4.62	27.00 ± 10.43	0.695	0.329	0.498
H-H Base of support (cm)	11.25 ± 5.68	11.39 ± 4.51	13.16 ± 6.52	0.893	0.459	0.455
Stance period (%GC)	70.60 ± 11.53	74.87 ± 12.04	72.15 ± 11.72	0.152	0.512	0.316

Post-hoc comparisons with Bonferroni adjustment. [a]Free walk vs. cane walk. [b]Free walk vs. wheeled walk. [c]Cane walk vs. wheeled walk; significant at $p < 0.017$.

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immediately compromised walking speed in individuals with PD, whereas ambulation with a wheeled walker compromised walking speed and stride length.

Chong *et al*. reported no difference in walking speed between unsupported and supported walking in persons with PD [13]. The discordance may be due to difference in the study design. The subjects in our study walked only one trial, whereas the subjects in Chong's study walked three trails and the best walking speed was used in the data analysis. A learning effect might have occurred from the repeated trials. We used a wheeled walker with height adjusted to fit each subject, whereas a trolley was used in the supported walk in Chong's study. Our walking test was performed when the subjects were in their medicated state, whereas non-medicated subjects were tested in Chong's study. Effect of anti-parkinsonian medications on gait modification during assisted walk in persons with PD has not been reported.

Only 33% of a sample of 144 cane users received clinician advice when selecting a walking device, which can lead to an inappropriate selection and use [7]. This in turn can result in a poor gait pattern, which increases the risk of falls and energy expenditure [14, 15]. Our results showed that certain gait characteristics immediately modified when persons with PD first walked with walking devices. This finding supported the use of recommendation and additional training from healthcare workers in using a walking device. Slower self-selected gait speed and shortened stride length have been related to risk of falls in the elderly [16, 17]. From our results, a slow gait speed and shortened stride length when first walked with the walking devices may predispose individuals with PD to instability and falls.

We did not find changes in the cadence, stride time, percentage of double support phase, heel to heel base of support and stance period when walking with the two walking devices compared to the unassisted walk. Ambulation with a cane showed a tendency to decrease both cadence and stride length, but did not reach the significant level. These tendencies may be attributed to decreased gait speed when using a cane. Slower gait speed when using a wheeled walker was explained by the shortened stride length. Percentage of double support and heel to heel base of support during assisted walk with the two walking devices did not change. In the other word, the assisted walk did not immediately change the stability when compared to unassisted walk.

Study limitations

There are several limitations of the study. First, generalizability of the study may be limited by the small sample size of 10 participants. Second, we used a single-tip support cane and a four-wheeled walker in this study because they are commonly used mobility aids in persons with PD. Other walking devices including a quad cane, (four-point cane) and a two-wheeled walker are also often used by individuals with PD. Gait changes by these devices may differ from our results. Third, there was no healthy control group in the study to compare the gait changes with the walking devices. Forth, the order of walking condition was not randomized and this might introduce carry-over effect. However, we did provide rest period between the walking conditions to minimize the possible carry-over effect. Finally, this study demonstrated the immediate gait modifications when using a single point cane and a wheeled walker for ambulation, long-term effects in persons with PD remain unknown.

Conclusion

The results provide initial clinical evidence regarding how persons with PD modified their gait when walking with different devices. Clinicians should be cognizant of these modifications during gait rehabilitation. The results may be helpful in providing properly additional gait training in persons with PD when prescribing ambulatory devices.

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Appendix A. Definition of spatial parameters (Figure 1).

Stride length is measured on the line of progression between the heel points of two consecutive footfalls of the same foot. AG represents the stride length of the left foot. H-H base of support or base width is the` perpendicular distance from heel point of one footfall to the line of progression of the opposite foot. The H-H base of support is depicted by the line (DL), which is the base-width of the right foot.

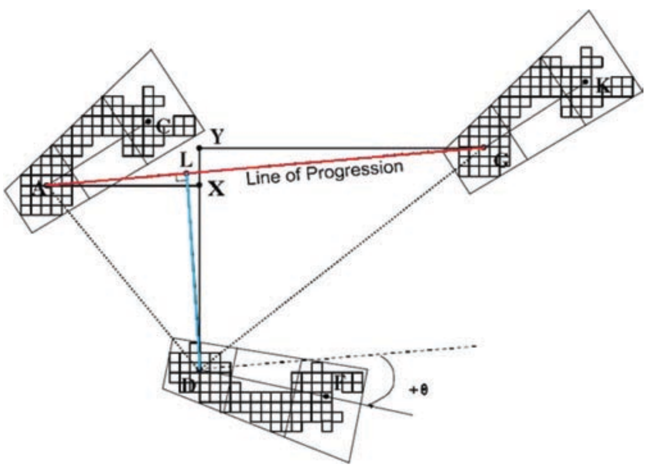

Figure 1. Line AG represents stride length. Line DL represents H-H base of support [11].

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