Gait & Posture 62 (2018) 405–408

Contents lists available at ScienceDirect

Gait & Posture

journal homepage: www.elsevier.com/locate/gaitpost

Short communication

Objective measures of unobstructed walking and obstacle avoidance in Parkinson's disease subtypes

Diego Orcioli-Silva[a,*], Rodrigo Vitório[a], Ellen Lirani-Silva[a], Paulo Cezar Rocha Santos[a,b], Victor Spiandor Beretta[a], Lilian Teresa Bucken Gobbi[a]

[a] São Paulo State University (UNESP), Institute of Biosciences, Posture and Gait Studies Laboratory (LEPLO), Rio Claro, Brazil
[b] University of Groningen, University Medical Center Groningen, Center for Human Movement Sciences, Groningen, The Netherlands

ARTICLE INFO

Keywords:
Gait
Obstacle avoidance
Parkinson's disease
PIGD
Tremor dominant

ABSTRACT

Background: Objective measures of gait in Parkinson's disease (PD) patients according to motor subtypes are not yet fully understood. Although recent advances have been made for unobstructed walking, further work is required on locomotor tasks challenging postural stability, such as obstacle avoidance.
Research question: This study aimed to investigate the influence of PD motor subtypes on objective measures of locomotion during unobstructed walking and obstacle avoidance.
Methods: Thirty-five PD patients classified as postural instability and gait disorder (PIGD) and 30 as tremor dominant (TD), as well as 45 healthy controls (CG) walked along an 8-m pathway under two conditions: (a) unobstructed walking and (b) obstacle avoidance. Outcome measures included spatiotemporal parameters recorded by an optoelectronic tridimensional system.
Results: During unobstructed walking, the PIGD group exhibited shorter stride length, slower velocity, and longer double support phase compared to the TD and CG groups. The TD group also presented slower stride velocity compared to the CG. The PIGD and TD groups presented shorter stride duration than the CG. Regarding obstacle avoidance, the PIGD group exhibited shorter distances for leading foot placement before obstacle, trailing foot placement after obstacle and trailing crossing step length compared to the TD and CG groups. The PIGD group exhibited wider leading crossing step width, lower trailing toe clearance, and slower leading and trailing velocity during obstacle avoidance compared to the CG.
Significance: PIGD subtype patients showed worse modifications in objective measures of unobstructed walking and obstacle avoidance. The observed modifications may contribute to increased fall occurrence in PIGD patients.

1. Introduction

Parkinson's disease (PD) is a heterogeneous neurodegenerative disorder with variable clinical characteristics [1]. Typically, patients are classified into different motor subtypes, including tremor dominant (TD) and postural instability and gait disorder (PIGD). TD is characterized by the predominant presence of tremors and PIGD is associated with more severe gait impairments, postural instability, bradykinesia, rigidity, and falling [1–4]. The influence of PD motor subtypes on objective measures of locomotion has not yet been fully understood. Although recent advances have been made for unobstructed walking (with conflicting findings) and dual tasking [3,4], further work is required on locomotor tasks challenging postural stability (e.g., obstacle avoidance). To date, previous studies have shown that obstacle avoidance is impaired in patients with PD [5–7], but with no clear information regarding PD subtypes. The development of this knowledge may help to better understand the differences between PIGD and TD subtypes and to tailor therapy. Thus, this study aimed to investigate the influence of PD motor subtypes on objective measures of locomotion during unobstructed walking and obstacle avoidance. We hypothesized that objective measures of unobstructed walking and obstacle avoidance would be worse among patients in the PIGD subtype.

2. Methods

2.1. Participants

Seventy-six patients with PD and 45 healthy controls (CG) were

* Corresponding author at: São Paulo State University (UNESP), Bioscience Institute, Campus Rio Claro, Posture and Gait Studies Laboratory (LEPLO), Avenida 24-A, 1515, Bela Vista, 13506-900, Rio Claro, SP, Brazil.
E-mail address: diegoos@rc.unesp.br (D. Orcioli-Silva).

https://doi.org/10.1016/j.gaitpost.2018.03.046
Received 22 September 2017; Received in revised form 26 February 2018; Accepted 27 March 2018

recruited. Patients with PD were classified into PIGD (n = 35), TD (n = 30), or indeterminate (n = 11) according to the procedures proposed by Jankovic et al. [1]. Patients with PD were included if they were: (a) diagnosed with idiopathic PD (b) in Hoehn and Yahr (HY) stages I-III; and (c) taking PD medication. Participants were excluded if they had a diagnosis of dementia or co-morbidities likely to affect gait. The Unified Parkinson's Disease Rating Scale (UPDRS) [8] and the HY [9] were used to determine the severity and stage of the disease in the patients with PD. Global cognition of all participants was assessed using the Mini Mental State Examination (MMSE) [10]. Patients within indeterminate subtypes were excluded from further analysis. PD groups were tested during the "on state" of PD medication. All participants self-reported the number of falls during the previous 12 months. This study was approved by the local ethics committee. All subjects gave written informed consent.

2.2. Procedures

Gait was assessed under two conditions (at self-selected speed): unobstructed walking and obstacle avoidance. The obstacle was set up at half knee height × 60 cm width × 3 cm depth [6]. The obstacle was positioned in the middle of a pathway (8 m long). Three unobstructed walking trials and six obstacle avoidance trials, comprising equal numbers of left and right crossing steps (fully randomized) were analyzed.

Gait parameters were recorded using an optoelectronic tridimensional system (OPTOTRAK Certus, 100 Hz), positioned in the right sagittal plane. Four active markers were attached to the 5th metatarsal and lateral face of the calcaneus of the right foot and 1st metatarsal and medial face of the calcaneus of the left foot. One marker was fixed at the top edge of the obstacle. Marker trajectories were filtered with a fifth-order Butterworth low-pass filter, with a cutoff frequency of 6 Hz. The spatiotemporal parameters of unobstructed walking (mid-pathway right stride) and obstacle avoidance (mean of six trials) (Fig. 1) were calculated using an algorithm created in Matlab 7.0 (The Maths Works Inc.). Further details about data processing and outcome variables can be found in earlier studies by our group [6,7].

2.3. Statistical analysis

Demographic data were analyzed by ANOVA, Pearson's Chi-square test (sex), and independent-samples *t*-test (PD-related). Spatiotemporal parameters were analyzed by ANOVA; the mean value of three (unobstructed walking) or six trials (obstacle avoidance) was considered in the analysis ($p \leq 0.05$). The Bonferroni post hoc test was used to localize the differences among groups (*P*-value was adjusted).

3. Results

The group characteristics are shown in Table 1. As expected, PIGD patients reported a greater number of falls than TD patients and the CG. In addition, PIGD patients demonstrated worse scores in the UPDRS I, UPDRS II, and UPDRS total compared to TD patients.

For unobstructed walking (Table 2), the PIGD group presented shorter stride length ($p = 0.001$, $p < 0.001$), slower velocity ($p = 0.034$, $p < 0.001$), and longer double support phase ($p = 0.015$, $p = 0.002$) compared to the TD and CG groups. The TD group also demonstrated slower stride velocity compared to the CG ($p = 0.010$). In addition, the PIGD and TD groups presented shorter stride duration than the CG ($p = 0.013$, $p = 0.034$).

During obstacle avoidance (Table 2), the PIGD group exhibited shorter distances for leading foot placement before obstacle ($p = 0.05$, $p = 0.015$), trailing foot placement after obstacle ($p = 0.029$, $p < 0.001$), and trailing crossing step length ($p = 0.014$, $p < 0.001$) compared to the TD and CG groups. The PIGD group exhibited wider leading crossing step width ($p = 0.016$), lower trailing toe clearance ($p = 0.031$), and slower leading ($p < 0.001$) and trailing ($p < 0.001$) velocity during obstacle avoidance ($p = 0.001$) compared to the CG.

4. Discussion

The current study compared PIGD and TD subtypes of PD during unobstructed walking and obstacle avoidance. Our findings confirmed our hypotheses, supporting that the objective measures of both walking conditions are worse in PIGD patients. Hypometria and bradykinesia are exacerbated in PIGD patients in both unobstructed walking and obstacle avoidance.

Regarding unobstructed walking, it is important to highlight that

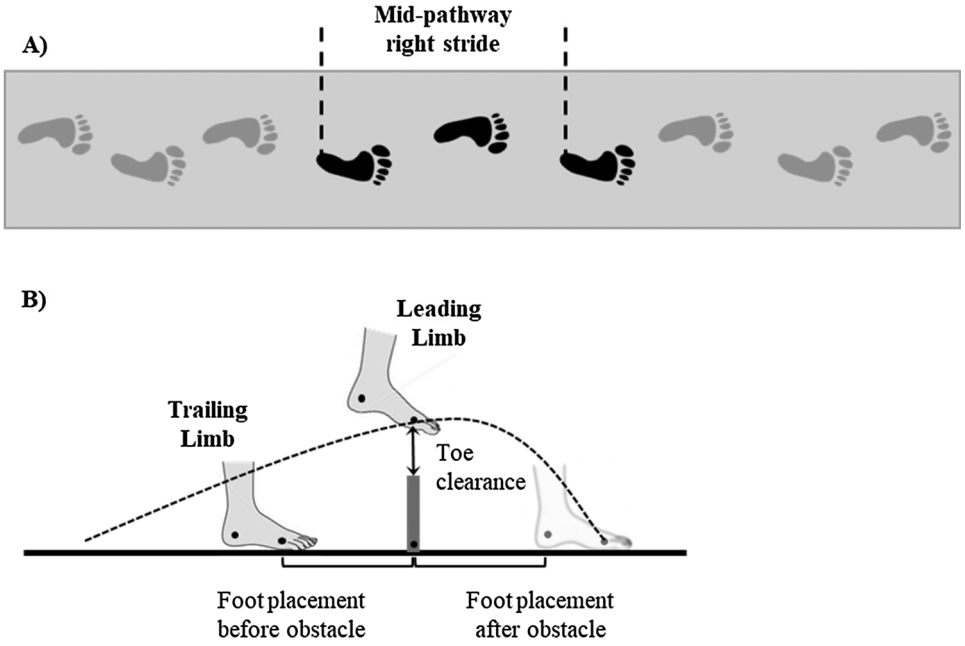

Fig. 1. Representation of the spatial dependent variables during unobstructed walking (A) and obstacle avoidance (B).