Gait & Posture 40 (2014) 266–269

Contents lists available at ScienceDirect

Gait & Posture

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

Short Communication

Disease severity affects obstacle crossing in people with Parkinson's disease

Rodrigo Vitório [a,*], Ellen Lirani-Silva [a], André Macari Baptista [a], Fabio Augusto Barbieri [a], Paulo Cezar Rocha dos Santos [a], Claudia Teixeira-Arroyo [a,b], Lilian Teresa Bucken Gobbi [a]

[a] UNESP, São Paulo State University at Rio Claro, 1515 24-A Avenue, Rio Claro, São Paulo State 13506-900, Brazil
[b] Centro Universitário UNIFAFIBE, 325 Prof. Orlando França de Carvalho Street, Bebedouro, São Paulo State 14701-070, Brazil

ARTICLE INFO

Article history:
Received 26 June 2013
Received in revised form 21 February 2014
Accepted 3 March 2014

Keywords:
Parkinson's disease
Obstacle avoidance
Disease severity
Gait

ABSTRACT

The current study evaluated the effects of disease severity on the control of obstacle crossing in people with idiopathic Parkinson's disease (PD). Forty-five subjects participated in the study, including 15 patients with mild PD (classified as stage 1 to 1.5 of the Hoehn and Yahr Rating Scale), 15 patients with moderate PD (classified as stage 2 to 3 of the Hoehn and Yahr Rating Scale), and 15 neurologically healthy individuals. Groups were matched by sex, age, body mass, and body height. The obstacle crossing task required participants to walk along a pathway and step over an obstacle (half of the knee height, positioned in the middle of the pathway). Patients were tested in a typically medicated state. Kinematic data were recorded using an optoelectronic tridimensional system. The outcome measures included spatiotemporal measures of obstacle avoidance. There were no significant differences between patients with mild PD and healthy individuals. Patients with moderate PD exhibited shorter distances for leading toe clearance and leading foot placement after the obstacle than did healthy individuals. Patients with moderate PD tended to exhibit a lower leading horizontal mean velocity during obstacle crossing than did healthy individuals. We found significant negative relationships between obstacle crossing measures and disease severity (score on the motor section of the Unified Parkinson's Disease Rating Scale). These findings suggest that disease severity affects locomotor behavior during obstacle crossing in PD. Specifically, obstacle avoidance was not affected in the early stages of PD; however, bradykinesia and hypometria influenced obstacle crossing in patients with moderate PD.

1. Introduction

Tripping over obstacles is one of the major causes of falls in people with Parkinson's disease (PD) [1]. One possible explanation for this is the fact that the ability to adequately avoid obstacles is impaired in patients with PD [2–4]. To date, bradykinesia [2] and hypometria [4] have been demonstrated to compromise obstacle avoidance in patients with PD. In addition, postural stability, which is crucial during obstacle avoidance, deteriorates as PD progresses [5]. To our knowledge, the effects of disease severity on obstacle crossing in patients with PD have not yet been investigated. Thus, the aim of current study was to verify the effects of disease severity in the control of obstacle crossing in people with idiopathic PD. Considering that PD is a progressive pathology and disease severity is a strong predictor of comfortable and fast-as-possible gait speeds in PD [6], we hypothesized that disease severity in patients with PD can influence locomotor behavior while the patient is crossing an obstacle on the ground. We expected to observe mild alterations in spatiotemporal measures of obstacle avoidance in patients with mild PD and more pronounced alterations in these measures in patients with moderate PD.

2. Methods

2.1. Participants

This study adhered to the guidelines of the Declaration of Helsinki, and it was approved by the local ethics committee (Process #3439/2010).

Forty-five right-handed subjects participated in the study, including 15 patients with mild PD (classified as stage 1 to 1.5 of the modified Hoehn and Yahr Rating Scale [7]), 15 patients with

* Corresponding author. Tel.: +55 19 3534 6436; fax: +55 19 3534 6436.
E-mail address: vitoriorodrigo@gmail.com (R. Vitório).

http://dx.doi.org/10.1016/j.gaitpost.2014.03.003
0966-6362/

moderate PD (classified as stage 2 to 3 of the modified Hoehn and Yahr Rating Scale), and 15 neurologically healthy individuals. Groups were matched by gender, age, body height, and body mass. A neuropsychiatrist performed a clinical assessment to determine the stage of the disease in each patient and to test them on the motor section of the Unified Parkinson's Disease Rating Scale (UPDRS). Both patients with PD and healthy individuals were given the Mini-Mental State Examination (MMSE). The inclusion criteria were independent walker, no cognitive impairment, and no musculoskeletal or cardiorespiratory impairments. Those with PD were tested 1 h after taking their regular dosage of anti-Parkinsonian medication. The Levodopa equivalent dose was calculated according to Tomlinson's suggestions [8]. It is also important to attest that no PD patient suffered from freezing of gait.

2.2. Obstacle crossing task

The obstacle crossing task required participants to walk along a pathway (8 m long by 1.4 m wide) at their preferred speed and to step over an obstacle (half of the knee height × 600 mm × 30 mm) [4]. The obstacle height was standardized to offer the same relative challenge to all participants. The obstacle was positioned in the middle of a pathway that was covered with a black rubber carpet (3 mm thick). Three trials were performed. Participants were instructed to step over the obstacle with the right limb, which was considered the leading limb, while the left limb was considered to be the trailing limb.

Kinematic data were recorded using an optoelectronic tridimensional system (OPTOTRAK Certus®, Northern Digital Inc., Waterloo, Ontario, Canada). Four markers were attached to the following anatomic landmarks: (a) the 5th right and 1st left metatarsal joints, and (b) the lateral face of the right calcaneus and the medial face of the left calcaneus. Additionally, two markers were fixed at the obstacle, one at the base and another at the top edge. Data from the central area of the pathway were recorded at a frequency of 100 Hz. Raw data were filtered using a low-pass, 2nd-order digital Butterworth filter, with a cut-off frequency defined by a residual analysis for each coordinate of each marker in one trial in the Matlab 6.5 environment. Missing data were interpolated using cubic spline interpolation. Outcome measures included spatio-temporal parameters of obstacle avoidance: leading and trailing foot placement before the obstacle (horizontal distance from the metatarsal marker to the marker at the base of the obstacle), leading and trailing toe clearance (vertical distance from the metatarsal marker to the marker at the top edge of the obstacle at the moment of crossing), leading foot placement after obstacle crossing (horizontal distance from the right calcaneus marker to the marker at the base of the obstacle), crossing step width (left foot width plus mediolateral distance between the metatarsal markers at the moment of the right foot contact of the crossing step), and leading and trailing horizontal mean velocity during obstacle crossing. We also recorded the number of obstacle contacts through visual inspection. When an obstacle contact occurred, the trial was immediately repeated (only successful trials were considered for data analysis).

2.3. Statistical analysis

The Gaussian distribution of the dependent and demographic variables was tested using the Shapiro–Wilk W test. The Levodopa equivalent dose was the only parameter that did not exhibit normal distribution. Demographic data were analyzed by a one-way analysis of variance (ANOVA; age, body height, body mass, and MMSE), the unrelated sample Student t-test (UPDRS motor section), and the Mann–Whitney test (Levodopa equivalent dose). Kinematic data were analyzed by one-way ANOVA; the mean value of three trials was considered in the analysis. Significance was set at $p \leq 0.05$. Tukey's post hoc test was used to localize the differences among groups. Additionally, Pearson's correlation analyses were conducted to assess the relationship between disease severity (score on UPDRS motor section) and obstacle crossing measures.

3. Results

The groups were not significantly different in terms of age, body mass, body height, MMSE, and Levodopa equivalent dose. As expected, patients with moderate PD demonstrated higher scores on the UPDRS motor section (more severe motor symptoms) than did patients with mild PD (Table 1). Only two obstacle contacts were observed: one was made by a patient with mild PD, and the other was made by a patient with moderate PD. Both obstacle contacts were made by the calf of the leading leg during the trajectory of the leading foot from the top edge of the obstacle to the floor. Importantly, these two obstacle contacts did not lead the patients to fall.

For the kinematic variables, there were no significant differences between patients with mild PD and healthy individuals. Patients with moderate PD exhibited shorter distances for leading toe clearance and leading foot placement after the obstacle than did healthy individuals. Additionally, patients with moderate PD tended to exhibit a lower leading horizontal mean velocity during obstacle crossing than did healthy individuals (Table 2).

Pearson's correlation analyses identified significant negative relationships between the UPDRS motor section score and the obstacle crossing measures (i.e., leading foot placement before the obstacle, leading foot placement after the obstacle, leading horizontal mean velocity during obstacle crossing, and trailing horizontal mean velocity during obstacle crossing; see Fig. 1 and Table 2).

4. Discussion

The current study investigated the effects of disease severity on the control of obstacle crossing in people with idiopathic PD. While patients with mild PD did not exhibit impairments during obstacle crossing, those with moderate PD exhibited shorter distances for leading toe clearance and leading foot placement after the obstacle than did healthy individuals. Patients with moderate PD tended to cross the obstacle slower with the leading limb compared with healthy individuals. Additionally, we observed moderate negative relationships between the UPDRS motor section score (disease severity) and some of the obstacle crossing measures (Fig. 1 and Table 2). In other words, as the disease progresses and becomes more severe, patients demonstrate more pronounced signs of

Table 1
Characteristics of patients with Parkinson's disease and control group.

Demographic measure	Mild PD	Moderate PD	Control group	Statistical values
Male/female	7/8	7/8	7/8	
Age (years)	69.4 ± 5.3	70.8 ± 6.9	70.7 ± 5.1	$F_{2,42} = 0.274$, $p = 0.762$
Body mass (kg)	70.2 ± 8.9	70.9 ± 15	67 ± 12.1	$F_{2,42} = 0.433$, $p = 0.651$
Body height (cm)	159.8 ± 8.9	160.2 ± 9.9	162 ± 7.2	$F_{2,42} = 0.275$, $p = 0.761$
MMSE (score)	27.6 ± 1.9	27.1 ± 3.8	27.5 ± 2.8	$F_{2,42} = 0.172$, $p = 0.843$
UPDRS – motor section (score)	18.2 ± 5.6	28.9 ± 6.9		$t_{28} = -4.645$, $p < 0.001$
Levodopa equivalent dose (mg/day)	594.1 ± 293.2	643.1 ± 252.1		$U = 79.0$, $p = 0.163$