



Standing balance in individuals with Parkinson's disease during single and dual-task conditions



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ABSTRACT

This study aimed to examine the differences in standing balance between individuals with Parkinson's disease (PD) and subjects without PD (control group), under single and dual-task conditions. A cross-sectional study was designed using a non-probabilistic sample of 110 individuals (50 participants with PD and 60 controls) aged 50 years old and over. The individuals with PD were in the early or middle stages of the disease (characterized by Hoehn and Yahr as stages 1–3). The standing balance was assessed by measuring the centre of pressure (CoP) displacement in single-task (eyes-open/eyes-closed) and dual-task (while performing two different verbal fluency tasks).

No significant differences were found between the groups regarding sociodemographic variables. In general, the standing balance of the individuals with PD was worse than the controls, as the CoP displacement across tasks was significantly higher for the individuals with PD ($p < 0.01$), both in anteroposterior and mediolateral directions. Moreover, there were significant differences in the CoP displacement based parameters between the conditions, mainly between the eyes-open condition and the remaining conditions. However, there was no significant interaction found between group and condition, which suggests that changes in the CoP displacement between tasks were not influenced by having PD.

In conclusion, this study shows that, although individuals with PD had a worse overall standing balance than individuals without the disease, the impact of performing an additional task on the CoP displacement is similar for both groups.

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1. Introduction

Parkinson's disease (PD) is a chronic, progressive and neurodegenerative disorder affecting over 4 million people worldwide [1,2]. Its symptoms can be categorized as motor and non-motor.

The four cardinal features of the disease are motor: tremor at rest, rigidity, bradykinesia and postural instability [3].

The postural instability impairs the ability to maintain standing balance during everyday activities and increases the risk of falling. This ability depends on the integrated functioning of proprioceptive, vestibular and visual systems, muscle properties and neural control [4]. The preservation of standing balance relies upon the ability to keep the body's centre of mass inside the base of support [5]. The corrective forces that control the centre of mass are usually measured by assessing the centre of pressure (CoP) displacement,

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which represents the point of application of all the ground reaction forces. Therefore, the CoP is commonly examined to detect subtle changes in standing balance [6].

Individuals with PD frequently resort to attentional strategies to maintain the postural stability and standing balance, due to the difficulty in achieving automaticity [7]. Consequently, several studies [8–10] have shown that these individuals have serious difficulties in processing simultaneous tasks adequately. In fact, when two tasks are performed at the same time by the individuals, the competition for limited resources results in dual-task interference and deterioration in the performance of one or both tasks. This further impairs the ability of the individuals to perform everyday activities [1,10].

As the dual-task interference on standing balance depends on the nature and complexity of the secondary task [11], researchers should focus on examining which tasks significantly affect this ability in individuals with PD. Consequently, this study aimed to analyze the differences in the standing balance between individuals with PD and without PD (control group), under single and dual-task conditions. Furthermore, the impact of performing an additional task on the standing balance was compared.

2. Methods

2.1. Study design and participants

A cross-sectional study was designed using a non-probabilistic sample of 50 individuals with PD and 60 controls. The individuals diagnosed with PD were from the São Sebastião Hospital, Santa Maria da Feira, in Portugal, and had been referred by their neurologist. These participants were 50 years old and over as in a previous research that has shown that the prevalence of this disease is significantly higher in this age group [12]. Consequently, in order to reduce the probability of having significant differences between the groups due to age, only individuals 50 years old or more were included in the control group. The control group was made up of community-dwelling subjects without PD that volunteered after information regarding the study was disclosed in community institutions, like social, recreation and day care centres, in Porto, Portugal.

The exclusion criteria were severe cognitive impairment, screened using the Mini Mental State Examination (MMSE) [13]. This exam used the following cut-off points: ≤ 22 for 0–2 years of literacy; ≤ 24 for 3–6 years; and ≤ 27 for ≥ 7 years, which are based on the normative values for Portuguese older adults [14] as its performance varies within the population according to the education level. Individuals that could not stand upright, walk short distances without assistance, unable to speak Portuguese were also excluded. Further exclusion criteria for individuals with PD were severe disability (>3 on the Modified Hoehn and Yahr Scale [15]), additional diagnosis of neuromuscular disease, and history of deep brain stimulation through subthalamic surgery. Controls that self-reported any neuromuscular disease were also excluded. However, taking into account that these individuals were community-dwelling individuals that volunteered to participate in the study, their medical doctor was not consulted. A trained researcher conducted the data collection, using a structured protocol. The individuals with PD were assessed in the São Sebastião Hospital and in the Portuguese Parkinson's Association in Porto. The controls were evaluated in the local community institutions through which they had first been contacted in order to be included in the study.

The study was approved by all the Institution's Ethical Review Boards and written informed consent, according to the Helsinki Declaration, was obtained from all participants.

2.2. Measurements

The data collected from all participants included sociodemographic characteristics (age, sex and level of education), use of a walking aid, body mass index (BMI), cognitive performance (assessed with MMSE [13]), standing balance in single and dual-tasks (examined by measuring of the CoP displacement using a pressure platform (Emed-AT25 D, from Novel Inc., Munich, Germany)), and number of words enunciated in the dual-task condition. The Modified Hoehn and Yahr Scale [15] and part III of the Unified Parkinson's Disease Rating Scale (UPDRS) [16] were also used to determine the severity of the impairment regarding the motor function of the individuals with PD. The latter information was provided by the individuals' neurologists immediately before the evaluation conducted in this study.

The participants' standing balance, both under single- and dual-task conditions, was assessed with a pressure platform, containing 4000 capacitive sensors within a sensing area of $380 \times 240 \text{ mm}^2$ (sensor resolution of 3 sensors/cm²), capable of acquiring the individual's plantar distribution, both in a static or dynamic form, as well as obtaining stabilometric measures, such as the CoP. Following previous studies [17,18], the CoP displacement based parameters studied were its maximum displacement (cm) in the anteroposterior (AP) and mediolateral (ML) directions, and its mean velocity (cm/s). For this measurement, each subject was asked to take off his/her shoes, step onto the platform, and maintain an orthostatic position for 60 s. The standing balance under single-task condition was assessed in two tasks: with eyes open (looking at a target placed two metres away at the height of the participants' eyes) and with eyes closed. In order to examine the standing balance under dual-task conditions, the participants were asked to maintain an upright standing position while performing two different verbal fluency tasks: semantic fluency task (enunciate the name of as many species of animals as possible) and phonemic fluency task (enunciate as many words as possible beginning with the letter R). These verbal fluency tasks were adapted from a previous study [19]. The order of each test changed randomly, from individual to individual, in order to avoid a learning effect and fatigue. The CoP based parameters were further analyzed considering the most stable 30-second period of each test.

The UPDRS [16], which was developed to monitor multiple aspects of PD related to disability and impairment, is made up of four parts, and is the most widely used scale for multicentre clinical trials in PD. Furthermore, this assessment tool has a satisfactory interrater reliability. Only the part III of the UPDRS scale was used in this study for the motor examination. The score given for each item varies from 0 to 4, from normal to severe; and the part III total score ranged from 0 to 52. This scale is often accompanied by the Modified Hoehn and Yahr Scale [15], which evaluates the severity of overall dysfunction in PD. This is a 7-point scale, in which each point is a different stage of the disease (stages 1–5, including 1.5 and 2.5). The scale increases with the severity of dysfunction along with the stage of the disease. All tests were carried out with the participants taking their prescribed medications, and were therefore denoted as "ON" medication, as in others studies [10,20].

2.3. Statistical analysis

According to the nature of the variables under study, descriptive statistical analyses were performed using proportions and measures of central tendency and dispersion.

Independent samples *t* test and chi-square test were performed to examine whether there were significant differences between the individuals with PD and the controls, for the sociodemographic

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