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Influence of dual-task on sit-to-stand-to-sit postural control in Parkinson's disease

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ABSTRACT

Postural control deficits are the most disabling aspects of Parkinson's disease (PD), resulting in decreased mobility and functional independence. The aim of this study was to assess the postural control stability, revealed by variables based on the centre of pressure (CoP), in individuals with PD while performing a sit-to-stand-to-sit sequence under single- and dual-task conditions.

An observational, analytical and cross-sectional study was performed. The sample consisted of 9 individuals with PD and 9 healthy controls. A force platform was used to measure the CoP displacement and velocity during the sit-to-stand-to-sit sequence. The results were statistically analysed.

Individuals with PD required greater durations for the sit-to-stand-to-sit sequence than the controls ($p < 0.05$). The anteroposterior and mediolateral CoP displacement were higher in the individuals with PD ($p < 0.05$). However, only the anteroposterior CoP velocity in the stand-to-sit phase ($p = 0.006$) was lower in the same individuals. Comparing the single- and dual-task conditions in both groups, the duration, the anteroposterior CoP displacement and velocity were higher in the dual-task condition ($p < 0.05$).

The individuals with PD presented reduced postural control stability during the sit-to-stand-to-sit sequence, especially when under the dual-task condition. These individuals have deficits not only in motor performance, but also in cognitive performance when performing the sit-to-stand-to-sit sequence in their daily life tasks. Moreover, both deficits tend to be intensified when two tasks are performed simultaneously.

1. Introduction

Parkinson's disease (PD) is considered the second most common neurodegenerative disorder, affecting about 1% of the world's current population [1,2]. Some projections indicate a large increase of this prevalence over the coming decades [2].

At the moment, the aetiology is explained by genetic predisposition and the presence of toxic environmental factors [3,4]. The majority of individuals with PD present an inadequate interaction between systems responsible for body balance, including the vestibular, visual and proprioceptive systems. Consequently, these individuals tend to shift their centre of gravity forward, and therefore, have difficulty to perform compensatory movements to require balance [5]. The transition from sitting to standing and standing to sitting are components of some everyday functional tasks that are highly demanding from a postural control perspective. In fact, the sit-to-stand-to-sit (STSTS) sequence implies the involvement of anticipatory postural adjustments (APAs) to movement performance [6–8]. Hence, the study concerning the STSTS sequence can contribute to clarify postural control requirements during daily activities. The variability and efficiency of functional movements require an appropriate postural control that depends on APAs to maintain stability of internal and external disturbances, taking into account the context and the

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task [9]. The planning of APAs involves various structures of the central nervous system (CNS), such as the pre-motor cortex, supplementary motor area, basal ganglia and cerebellum [10,11] that, through independent channels, convey information to the reticular formation, such as the pedunculopontine nucleus, which is important to modulate the APAs [12]. The neural connection between the basal ganglia and the pedunculopontine nucleus is through the corticostriatal-pallidum-pedunculopontine circuit, which is compromised in individuals with PD leading to postural control deficits. This is manifested in the changes in the activation of postural muscles in the form of APAs [10,13–15]. As the CNS is responsible for the motor modulation circuits, which are compromised in individuals with PD, there is a decrease in postural control and consequently, repercussions in the performance of tasks, like STSTS sequences [16–18]. This decreased postural control was demonstrated through CoP displacement variables. The CoP displacement reflects the orientation of body segments and corrective responses that control the centre of mass over the base of support [19], resulting from the combination of descending motor commands and the mechanical properties of the surrounding muscles [20]. In situations of dual-task, the use of cortical resources to perform motor tasks can affect or influence the performance of one or both tasks [21–23]. Despite the importance of the postural control stability for the STSTS sequence performance and the impact of PD on the postural control system, few studies have assessed these issues and only the sit-to-stand sequence has been addressed. Additionally, no study has evaluated this task under high cognitive demanding conditions. Based on these facts, the objective of the present study was to analyse the postural control stability in individuals with PD in single- and dual-task conditions. More specifically, the postural stability was assessed through representative CoP displacement variables in the anteroposterior and mediolateral directions (displacements and velocities), in the five phases of the STSTS sequence in single- and dual-task conditions. Based on the results obtained by Bhatt et al. [16] and on the neural dysfunction involving postural control pathways, a reduced postural control stability in individuals with PD can be hypothesised during the preforming of the STSTS sequence. This reduced stability would be amplified in these individuals when the STSTS sequence is performed in the dual-task condition.

2. Materials and methods

2.1. Study design and participants

A cross-sectional study was implemented using a non-probabilistic [24] sample of 9 individuals with PD and 9 healthy controls, aged between 52 and 80 years old. The individuals diagnosed with PD were patients from the Parkinson's Association, Porto, in Portugal, while the healthy controls were community-dwelling volunteers, mainly from Porto.

Subjects were excluded if they presented one of the following criteria: severe cognitive impairment (screened using the Montreal Cognitive Assessment (MoCA) test [25]); incapable of performing the sit-to-stand or stand-to-sit sequence independently; and unable to speak. Severely disabled PD patients (> 3 Hoehn and Yahr scale [26]), patients diagnosed with any other neuromuscular disease, and those who had undergone deep brain stimulation through subthalamic surgery or were taking cholinergic medication were also excluded. Healthy controls that had been diagnosed as adults with any neuromuscular disorder or that could not be considered sedentary according to the Centre for Disease Control for the American College of Sports Medicine, were also excluded [27].

A trained researcher conducted the data collection based on a structured protocol. The study was approved by the Ethical Review Board of "Escola Superior de Tecnologia da Saúde - Instituto Politécnico do Porto", in Portugal. Written informed consent, according to the Helsinki Declaration, was obtained from all participants.

2.2. Instruments

The data collected from all participants included the sociodemographic characteristics age, gender, height, weight and level of education, and years of disease, cognitive performance (assessed using the MoCA test), Hoehn and Yahr scale and the CoP data acquired using a force platform (model FP4060-8 from Bertec Corporation (USA)) under the single- and dual-task conditions.

The scale of Hoehn & Yahr (1967) evaluates the severity of overall dysfunction in individuals with PD. It is a 7-point scale, in which each point represents 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 [26]. The MoCA test consists of eight fields: visuospatial, nomination, memory, attention, language, abstraction, deferred evocation and orientation. The performance of an individual is calculated by the addition of the scores obtained in each of the domains, and the maximum that can be reached is equal to 30 points [25,28].

For the evaluation of the postural control, the data from the force platform was acquired at a sampling rate of 1000 Hz [29]. The platform was connected to a Bertec AM 6300 amplifier (USA) and in turn, this was connected to an analog-digital converter from Biopac Systems, Inc. (USA), and to an analog board of Qualysis Track Manager (Sweden) that can be used for stabilometric analyses. The stabilometric measurements comprise the assessment of balance in the orthostatic position through body movements, taking into account the anteroposterior (Fx), mediolateral (Fy) and vertical (Fz) components of the ground reaction force. For this, it is necessary to monitor the movement of the CoP in the anteroposterior (CoPAP) and mediolateral (CoPML) directions [30]. The signal related to the CoP movement was filtered using a fourth-order Butterworth low pass filter with a cut-off frequency of 20 Hz [31].

The attention level and consequently, the motor control perturbations were attained through a cognitive secondary task, namely the Stroop colour word test. This test consists in the enunciation of the visual colour instead of the written one. The number of errors and the number of named items were used for analysis [32] during a predefined time (60 s) for both groups.

2.3. Procedures

After an explanation of all the procedures involved, all individuals performed the study with shorts and standard shoes [33]. The height of the chair seat was adjusted to 100% of the lower leg length (from the knee joint to the ground), and 2/3 of the femur supported on the seat was used as a reference for the subjects to be considered in the sitting position. In the single-task condition, the subjects were asked to rise from sitting with a self-selected speed without using their upper limbs [34], then remain for 60 s in the standing position, looking at a point two meters away at eye level. After this interval, subjects were instructed to sit, again without any kind of support and at a self-selected speed. In the dual-task condition, all the previous procedures were repeated; however, the subjects were required to perform the Stroop test during the performing of the STSTS sequence [28]. The test words in different colours were projected on a wall at eye level. The subjects were instructed to name the colour instead of reading the word and no other specific instructions were given. The words were present according to each participant's responses during a pre-defined period of 60 s. A one minute rest between each trial was allowed, and the necessary repetitions were performed in order to obtain three valid trials for each subject.

The CoP displacement variables were analysed over the five phases of the STSTS sequence. For this, the sit-to-stand-to sit

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