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Full Length Article

Effort to reduce postural sway affects both cognitive and motor performances in individuals with Parkinson's disease

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ABSTRACT

Objectives: To assess the effects of voluntarily reducing postural sway on postural control and to determine the attention level needed to do so in healthy adults (n = 16, 65.9 ± 9.7) and persons with PD (n = 25, 65.8 ± 9.5 years). Tasks: quiet and still standing conditions with and without a category task. Cognitive performance, center of pressure (CoP) displacement variability (RMSCoP) and velocity (VCoP) were assessed in the anterior-posterior (AP) and medial-lateral (ML) directions.

Controls showed larger RMSCoP (AP) and VCoP (AP and ML) during still versus quiet standing ($p < 0.01$), while the PD group demonstrated no changes. In the PD group, RMSCoP and VCoP (ML) increased in still standing when performed with the cognitive task ($p < 0.05$). In both groups, cognitive responses decreased in still standing ($p < 0.05$).

In PD, attempting to reduce postural sway did not affect postural control under single task conditions, however ML CoP variability and velocity did increase as a dual task. In older adults, increased displacement and velocity in both AP and ML directions was observed during single, but not dual task conditions. Therefore standing still might not be an adequate postural strategy as it increases the attentional demand and affects motor performance, putting persons with PD at greater risk for falls.

1. Background

Postural instability is a major concern for individuals with Parkinson's disease (PD) as it affects simple everyday activities such as walking or standing (Morris, Iansek, Smithson, & Huxham, 2000). While healthy younger and older adults can adapt their postural strategies to changing environments, individuals with PD lack this ability, putting them at a higher risk for falls (Shaw, Stefanyk, Frank, Jog, & Adkin, 2012). When assessing risk of falls, it is important to determine the ability of a person to divide attentional resources and prioritize one task over another. It is widely accepted that attention is necessary during walking and standing activities; however, the effect that performing a secondary task has on postural stability (i.e. the ability to adequately maintain the body's center of mass within the base of support) is still subject to debate and is the source of many conflicting results in the available literature (Woollacott & Shumway-Cook, 2002). The type of secondary task, the level of difficulty of the task, and the population studied are amongst the main factors that have contributed to these inconsistencies. Several ideas as to what may impact postural stability in individuals with PD have been proposed. Morris et al. (2000) reported

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a larger decline in postural stability in individuals with PD compared to healthy individuals, most notably in those with a history of falls. In all three of their study groups, postural stability declined as postural tasks became more challenging (i.e. tandem standing) with the addition of internal or external perturbations, as well as when standing conditions were combined with a cognitive task. Nonetheless, a larger effect size in the PD groups suggests that dual tasking decreases the ability to control postural sway in individuals with PD and may increase their risk of falling (Morris et al., 2000).

Measures used to assess postural function are most commonly derived from the center of pressure (CoP) (Duarte & Freitas, 2010; Paillard & Noé, 2015). A larger center of pressure (CoP) displacement and velocity has generally been interpreted as an indicator of poorer postural control (Marchese, Bove, & Abbruzzese, 2003; Nantel, McDonald, & Bronte-Stewart, 2012; Pellecchia, 2003; Prieto, Myklebust, Hoffmann, Lovett, & Myklebust, 1996). This being said, previous studies have shown conflicting results, reporting either increased or decreased excursions of the CoP when performing a secondary task (Bloem, Grimbergen, van Dijk, & Munneke, 2006; Holmes, Jenkins, Johnson, Adams, & Spaulding, 2010; Marchese et al., 2003). It has also been suggested that individuals with PD may prioritize the secondary task over the primary motor task when performing a dual task, which could in turn lead to an increased risk of falls (Bloem et al., 2006). This finding is similar to that of Holmes et al. (2010), who reported a larger CoP excursion in individuals with PD as the cognitive load was increased during a quiet standing task. However, their results also showed a statistically smaller CoP displacement in individuals with PD compared to healthy older adults during the performance of a more complex task. Holmes et al. (2010) suggest that persons with PD may over-constrain their posture in preparation for complex cognitive tasks in an attempt to increase their postural balance. Such a strategy could be counterproductive in decreasing the risk of falling as it may impair the performance of voluntary movement and compensatory postural responses (Allum, Carpenter, Honegger, Adkin, & Bloem, 2002; Carpenter, Allum, Honegger, Adkin, & Bloem, 2004; Holmes et al., 2010; Wu, 1998). To date, the effect of voluntarily trying to reduce postural sway on postural control has yet to be assessed in individuals with PD. Furthermore, understanding the attentional resources needed to do so is important as it may provide useful insights into the impaired postural control mechanisms of those with PD and help develop fall prevention interventions specifically adapted for this population.

The purpose of our study is 1) to assess the effect of voluntarily attempting to reduce postural sway on postural control in individuals with PD, 2) to determine how the addition of a cognitive task affects motor and cognitive performance depending on the standing condition, and, 3) to compare postural strategies between healthy older adults and individuals with PD. We expect that attempting to restrain postural sway will have a larger effect on the postural stability of older adults compared to individuals with PD, while the addition of a cognitive task will have a greater effect on the postural stability of individuals with PD.

2. Methods

2.1. Participants

A sample of 25 participants (mean age: 65.8 ± 9.5 years, min: 37, max: 78 years; 21 male, 4 female) with PD (Dx: 6.5 ± 4.5 years; Hoehn and Yahr stages 0–3, Motor Unified Parkinson's Disease Rating scale 10.9 ± 4.5) recruited from the Parkinson's Disease and Movement Disorders Clinic of the city Hospital Research Institute and from the community, and 16 healthy older adult controls (mean: 65.9 ± 9.7, min: 40, max: 81; 4 male, 12 female) recruited from the community were included in the study. Participants in the PD group were tested on their normal anti-parkinsonian medication. Participants with orthopaedic, musculoskeletal, and neurological conditions other than Parkinson's disease with the potential to disrupt balance or gait were excluded from the study. The study was comprised mainly of standing tasks, therefore the inability to stand unassisted was also a criterion for exclusion. As participants were screened for all potential exclusion criteria before arriving at the laboratory, data from all participants included in the study are presented here. The study was approved by our institution's review board and each participant gave their written informed consent prior to their participation in the study.

Participants were asked to perform a sitting task followed by a series of standing trials, with and without a concomitant cognitive task. First, participants were seated one meter in front of a monitor and asked to perform a one-minute trial of a seated cognitive task. The task used was a verbal cognitive task, which consisted of the participant naming as many words as they could within a given category. For example, given the category *vegetables*, participants proceeded to name as many vegetables as they could out loud for the duration of the trial. Prior to beginning the task, participants were given a verbal count down from 3 to signal the start of the task. During the seated task (baseline), participants were shown one category on the monitor for the first 30 s of the trial, and a different category for the last 30 s of the trial, for a total trial duration of one minute. Responses were recorded during the task and later analyzed for response rate and errors made. Following the seated task, participants were directed to stand on a force platform, located in front of the monitor. Here, they completed standing trials under four different conditions while standing on a force platform: two quiet standing trials (with and without the category cognitive task) and two still standing trials (with and without the category cognitive task). For the quiet standing trials, participants were asked to stand as still as possible for one minute while facing forward and keeping their hands at their sides. For the still standing trials, participants were instructed once again to stand facing forward with their hands by their sides, however, this time they were instructed to stand as rigidly and as still as possible while engaging their muscles. Participants were provided with a verbal countdown from three to signify the beginning of each trial.