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Changes in postural control in patients with Parkinson's disease: a posturographic study

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Abstract

Objectives Postural instability is one of the most disabling features in Parkinson's disease (PD), and often leads to falls that reduce mobility and functional capacity. The objectives of this study were to analyse the limit of stability (LOS) and influence of the manipulation of visual, somatosensorial and visual–vestibular information on postural control in patients with PD and healthy subjects.
Design Cross-sectional.
Setting Movement Disorders Unit, university setting.
Participants Eighty-two subjects aged between 37 and 83 years: 41 with Parkinson's disease in the 'on' state and 41 healthy subjects with no neurological disorders. Both groups were matched in terms of sex and age.
Main outcome measures Unified Parkinson's Disease Rating Scale (UPDRS)–motor score, modified Hoehn and Yahr staging, Dynamic Gait Index (DGI) and posturography with integrated virtual reality. The parameters analysed by posturography were LOS area, area of body centre of pressure excursion and balance functional reserve in the standing position in 10 conditions (open and closed eyes, unstable surface with eyes closed, saccadic and optokinetic stimuli, and visual–vestibular interaction).
Results The mean UPDRS motor score and DGI score were 27 [standard deviation (SD) 14] and 21 (SD 3), respectively. Thirteen participants scored between 0 and 19 points, indicating major risk of falls. Posturographic assessment showed that patients with PD had significantly lower LOS area and balance functional reserve values, and greater body sway area in all posturographic conditions compared with healthy subjects.
Conclusions Patients with PD have reduced LOS area and greater postural sway compared with healthy subjects. The deterioration in postural control was significantly associated with major risk of falls.

Keywords: Postural balance; Parkinson's disease; Accidental falls; Movement disorders

Introduction

Postural control is the complex ability to maintain postural orientation and stability depending on dynamic interactions between distinct sensory systems (i.e. visual, vestibular, auditory and somatosensory) and motor processes [1]. Postural control involves the maintenance of the body's line of gravity within the base of support by means of compensatory and/or anticipatory strategies to prevent postural instability and subsequent falls.

Postural instability is common in patients with Parkinson's disease (PD) [2]. The patient's line of gravity tends to oscillate within and outside their base of support, and they may be

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unable to perform compensatory movements to regain body balance, which leads to increased fear of falling and actual falls [3,4]. Evaluation of postural control is useful to guide the rehabilitation process of patients with PD in order to reduce the risk of falls. Computerised posturography provides very accurate results on postural sway parameters, which cannot be obtained through clinical examination alone [5]. Despite the high costs, the advantages of this method include measurement of the limit of stability (LOS) and the body centre of pressure (COP) displacement in different sensory conditions, which predict the fall index. Computerised posturography does not evaluate important functional aspects, so additional clinical tests are required for a more comprehensive assessment of postural stability.

A previous study has demonstrated that patients with PD show little postural sway and decreased postural responses due to muscle stiffness and excessive contractions of antagonist muscles [6]. On the other hand, other studies have observed increased body sway in patients with PD [5,7–10]. It has been observed previously that, in the absence of visual cues, the center of contact pressure is shifted significantly backwards in patients with PD of Hoehn and Yahr (HY) Stages 3 and 4 [7]. The increased mediolateral postural sway in patients with PD of HY Stages 1 to 3 with eyes closed has been shown to be a useful clinical observation to identify postural instability and increased risk of falls [11]. Results from dynamic computerised posturography suggest that patients with PD of HY Stages 2 to 4 had worse scores than controls for overall balance, vestibular and visual inputs, demonstrating greater dependence on visual information, and reduced use of vestibular information for postural control [9]. These findings provide evidence that visual inputs contribute to the maintenance of a vertical position in patients with PD.

The assessment of postural control in patients with PD exposed to different sensory environments (i.e. eyes open, eyes closed, visual input changing from a stable to a moving visual field) is a key component for guiding postural control rehabilitation and fall prevention programmes. Moreover, a limited number of studies have addressed LOS in patients with PD [12–14]. The posturography module of the Balance Rehabilitation Unit (BRU) [15,16] is an integrated virtual reality system equipped with virtual reality goggles, a static force platform and software that measures postural control in 10 different sensory conditions. The aim of this study was to quantify LOS and to analyse the influence of visual, somatosensory and visual–vestibular inputs on the postural control of patients with PD and healthy subjects.

Subjects and methods

Subject selection

The study was approved by the Federal University of São Paulo [Universidade Federal de São Paulo (UNIFESP) Committee on Ethical and Regulatory Norms under Protocol 1468/10. All participants or caregivers signed the informed consent form. In total, 82 subjects, aged 37 to 83 years, participated in this cross-sectional study. Subjects were distributed in two groups.

The experimental group was composed of 41 patients diagnosed with PD based on the UK Brain Bank criteria [17]: 12 females and 29 males with a mean age of 61 [standard deviation (SD) 11] years. All patients were assessed regularly at the Movement Disorders Unit of the Department of Neurology and Neurosurgery at UNIFESP. The estimated sample size was based on previously collected posturography data with α of 0.05 and power of 0.80. The exclusion criteria were: HY Stage >3, uncontrolled dyskinesia or unpredictable motor fluctuation, reduced visual acuity, previous history of other neurological or vestibular disease, dizziness, arthritis, recent injury, prior closed head injuries, heavy use of alcohol, use of recreational drugs, other conditions that could affect postural control, and unable to understand and fulfil the questionnaires. All patients with PD were examined during their best clinical condition ('on' state), approximately 40 minutes after taking PD medication.

The age-matched control group of healthy subjects consisted of 41 volunteers (19 females and 22 males) with no neurological or orthopaedic disorders, no history of falls in the past 6 months, and no complaints of imbalance, dizziness, dementia, weakness or peripheral sensory loss that could affect posturographic testing. The healthy subjects had no exposure to psychotropic drugs or alcohol within the 24 hours preceding the evaluation. The mean age of the healthy subjects was 62 (SD 12) years.

Clinical protocol

All patients were evaluated by a single neurologist and physiotherapist with experience in PD using multiple assessment instruments: Unified Parkinson's Disease Rating Scale (UPDRS) motor scores (Part III) [18], modified HY staging [18], modified Schwab and England Capacity for Daily Living Scale (S&E ADL) [18], Dynamic Gait Index (DGI scores ≤19 indicate major risk of falls, scores >19 indicate minor risk of falls) [19,20] and computerised posturography [15,16]. The equivalent daily dose of L-dopa was calculated using a published formula for conversion [21].

Computerised posturography

The BRU (Medicaa, Montevideo, Uruguay) is a computerised posturography system, integrated with a virtual reality system, that measures postural sway resulting from different stimuli. It uses information on the position of the subject's COP during tasks performed on the balance platform (450 × 450 mm). The BRU software sends a stimulus to a head-mounted display (HMD; eMagin Z800 3D Vision, New York, NY, USA) eliciting oculomotor reflexes (saccades, optokinetic and vestibulo-ocular) [15].