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Correlation of impaired subjective visual vertical and postural instability in Parkinson's disease

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ABSTRACT

Perception of verticality is essential for postural control. On the other hand, postural instability is one of the cardinal features in Parkinson's disease (PD). Thus, the objective of this study was to evaluate the vertical perception using the subjective visual vertical test in PD patients with different degrees of postural instability and in different stages of disease. Forty five idiopathic PD patients were evaluated using the Unified Parkinson's Disease Rating Scale (UPDRS), the Hoehn and Yahr Scale, the clinical test for postural instability, and the subjective visual vertical test. Forty-five healthy individuals were evaluated in the control group. PD patients had a compromised perception of verticality and a disturbed processing of graviceptive pathways. Good correlation was also found between subjective visual vertical and postural instability. Patients with the worst postural instability had greater deviations of subjective visual vertical. There was also a positive correlation between subjective visual vertical and scores on the UPDRS and Hoehn and Yahr Scale, with good and reasonable degree of intensity, respectively. These findings suggest that the perception of verticality is affected in PD patients and this abnormal vertical perception and disturbed processing of graviceptive pathways are associated with postural instability and to a lesser degree with disease severity.

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1. Introduction

Postural instability is one of the cardinal features of Parkinson's disease (PD). Further, 50–70% of patients with PD experience falls [5]. These falls are caused by festination, freezing, levodopa-induced dyskinesias symptomatic orthostatic hypotension and postural instability [5]. Impairment of postural responses in PD is probably the leading cause of falls when patients change position, however, the physiopathology of postural instability in patients with PD has not been well described. Falls can occur despite treatment with levodopa, suggesting that the postural instability in advanced stages of PD is dopa-resistant [8,23].

The model of physiology of posture proposes the existence of two levels of control. The first level is of perception of body schema and the second one is of motor control and postural stabilization. The first level includes the representation of the body geometry, of body kinematics and of body orientation with respect to vertical. The contributions of the somatosensory, visual and vestibular systems are different for each of these representations and for diverse environmental and task conditions. The geometric representation of the body depends mainly on the proprioceptive inputs, which informs the central nervous system about the position of each joint with respect to other parts of the body. The representation of body kinetics consists of the central nervous system's evaluation of the support conditions. This depends on the foot sole receptors and the proprioceptive inputs in the ankle joints. Finally, perception of verticality depends on multimodal sensory input. The otolith organs (utricle and saccule) sense linear accelerations, including those produced by gravity. Thus, they play a major role to detect gravitational input and head position related to earth vertical. The afferents provided by the otolith organs are interpreted together with visual information and proprioceptive signals from head–neck and neck–trunk positions. A lesion of the graviceptive pathways (from the otolith organs – utricule and saccule – to the cortex) produces an otolithic tone imbalance. Perception of body verticality is also estimated by proprioceptive signals and possibly by body graviceptors. So, perception of verticality depends on sensors located in the head (otolith organs) and on body sensors [25]. Disturbance of any of these systems and sensory inputs may be involved in postural instability.

Most of the studies regarding postural disorders in PD have focused on the implementation of postural stabilization and motor control. Little attention has been given to perception of body schema, specially to the perception of verticality [3,5]. Patients with advanced PD and impaired balance when tested under altered sensory conditions on computerized dynamic posturography had an abnormal sensory organizational process for postural control [11,34]. Investigators have used different methods to evaluate vestibular function in patients with PD or parkinsonism, including caloric tests [33], galvanic vestibular stimulation [30], and computerized dynamic posturography [34]. Some studies

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have indicated that parkinsonian patients have a deficit in processing of proprioceptive [18,39] and vestibular [33,34] information, which contributes to postural instability.

Studies that evaluated vertical perception using the subjective visual vertical (SVV) emphasized that the abnormal adjustments might be associated with disease severity, [12] to the predominantly affected side of the brain [2,32] or could be indicative of an increased visual dependence in PD [1]. However, a possible correlation of an impaired SVV perception and postural instability has not been analyzed.

Based on this information, the objective of this study was to evaluate the perception of verticality using the SVV test in PD patients able to stand unaided, but with different degrees of postural instability and different stages of disease.

2. Methods

2.1. Subjects

2.1.1. Inclusion criteria and control group

Forty five patients (aged between 34 and 84 years, mean 64.5 years, standard deviation 12.3, 25 males) from the Movement Disorders Unit of the Neurology Department at University of São Paulo Medical School, diagnosed with idiopathic PD according to United Kingdom Parkinson's Disease Society Brain Bank clinical criteria [15] and 45 healthy controls (aged between 35 and 85 years, mean 63.2 years, standard deviation: 10.6, 25 males) were included in the study. Patient and control groups did not differ significantly with respect to age or gender distribution. The mean duration of PD was 9.7 ± 6.8 years. All experiments were conducted in accordance with the Declaration of Helsinki and this study was approved by the local Research Ethics Committee. All patients and controls signed the informed consent term.

2.1.2. Exclusion criteria

PD patients and healthy controls were excluded from this study if they presented (1) history of vestibular symptoms, vestibular disease or abnormal vestibulo–ocular reflex; (2) auditory disturbance; (3) cognitive disorders, as scored by part I of standard UPDRS; (4) severe visual accuracy impairment; (5) stroke history; (6) peripheral neuropathy or (7) cervical dystonia.

2.2. Clinical assessment of PD patients

Forty five patients were submitted to complete neurologic examination. To access specific neurological functions, that could exclude the patient, the following tests were performed: Romberg test; vestibular tests — vestibulo–ocular reflex, identification of possible spontaneous, gaze evoked and/or provocation nystagmus; auditory tests – Rinne, Weber and Schwabach; and visual accuracy – evaluation with Rosenbaum card. As all patients were under treatment with levodopa and/or dopamine agonists, with different dosages and dosing intervals, the evaluation of manifestations of PD was performed during their medicated state. The examiner applied the following scales: the "shoulder-pull, expected" clinical test for postural instability and part of the Short Parkinson Evaluation Scale [41] the Hoehn and Yahr Scale (HY) and the standard UPDRS. Patients were divided into three groups of postural instability, according to score on the postural instability scale as follows: (0) normal, may take 2 steps to recover; (1) retropulsion, but recovers unaided; (2) retropulsion, but will fall if unaided; and (3) unable to stand unaided. This last group was excluded from this study due to the severity of this stage of disease, often associated with cognitive disorders and other factors (freezing, severe rigidity and bradykinesia,) that interfere with motor performance. The same person did all the evaluations, so that a possible bias due to test performance was minimized.

2.3. Subjective visual vertical

2.3.1. Subjective visual vertical test

The measurement of the SVV was performed in PD patients and healthy controls using a 24 cm long luminous portable rod. The rod was positioned 1.5 m in front of the subject who was sitting upright and wearing glasses with dark lenses that made use of any other visual reference impossible (Fig. 1). Patients remained sitting and the head was aligned with trunk position. Measurements were stopped if the head tilted to either side. Starting from an oblique position, with equal number of clockwise (positive) and counterclockwise (negative) initial positions, the subject verbally instructed the examiner to set the rod into a vertical position. Both, healthy controls and PD patients made ten adjustments. The same person evaluated the pull test and the SVV, and clinical evaluation, including the pull test, were completed and scored prior to the SVV test.

2.3.2. Subjective visual vertical theory and calculation

Two different SVV-analyses were performed. In the first analysis the objective was to detect otolithic tonus imbalance, since SVV tilts are known to be a sensitive sign of otolithic tone imbalance and a lesion of the graviceptive pathways. These SVV tilts were calculated as a mean value and expressed as either clockwise or anticlockwise. The values of SVV-deviations from true vertical to the right (clockwise) of the subject examined were considered positive, while deviations to the left (anticlockwise) were deemed negative, and a mean value was calculated. A second analysis was done to detect intraindividual variability. An intraindividual variability implies a compromised perception of verticality and a disturbed processing of the graviceptive pathways, but not necessarily an otolithic tone imbalance. In this analysis, the absolute values of SVV-deviations were considered, since increased shift for either direction of rotation may be symmetrical and a normal mean value may not be representative of abnormal deviations.

2.4. Statistical analysis

The Mann–Whitney test was used to compare the mean and absolute mean values of SVV between PD patients and healthy controls. The Kruskal–Wallis test was used to identify differences in SVV-deviations among postural instability groups. Spearman's correlation test was used to assess the association between the SVV-deviations and scores on the UPDRS, HY and postural instability scales. The r-values were classified as follows: $r < 0.4$ poor correlation; $0.4 < r < 0.6$, moderate correlation; $r > 0.6$ strong correlation. A post-hoc analysis was conducted for the comparisons made using the Kruskal–Wallis test and for this purpose Tukey's test was used. The level of significance was 5%.

3. Results

3.1. Characteristics of all patients: postural instability, HY and UPDRS scales

Based on the "shoulder-pull, expected" clinical test and scale, 45 patients were distributed into three postural instability groups: Group 0 — normal, may take 2 steps to recover (n = 16); Group 1 — retropulsion, but recovers unaided (n = 15) and Group 2 — retropulsion, but will fall if unaided (n = 14). On the HY scale, patients scored between 1.0 and 4.0, with a median of 2.50, confidence interval (CI) = 2.0 to 3.0. Score 1 means that the patient has unilateral disease with a minimal disability, and score 4 means that the patient has severely disabling disease, but is still able to walk or stand unassisted. On the UPDRS scale patient scores ranged from 11 to 103, with a median of 41, 96.4% CI = 35 to 48. This scale has 42 items and ranges from 0: no impairment and 199: total incapacity, so that most scores showed a mild disability.

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