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What Could Posturography Tell Us About Balance Problems in Parkinson's Disease?

*Marcos Rossi-Izquierdo, †Andrés Soto-Varela, ‡Arne Ernst, *Juan Pedro Rubio-Rodríguez, †Sofía Santos-Pérez, §Ángel Sesar, ||Miguel Alberte-Woodward, ||Mónica Guijarro-Del Amo, *Elena San Román-Rodríguez, †Ana Faraldo-García, *Alfonso Zubizarreta-Gutiérrez, and ‡Dietmar Basta

**Department of Otolaryngology, University Hospital Lucus Augusti, Lugo; †Department of Otolaryngology, University Hospital of Santiago de Compostela, Santiago de Compostela, Spain; ‡Department of Otolaryngology at UKB, Hospital of the University of Berlin, Charité Medical School, Berlin, Germany; §Department of Neurology, University Hospital of Santiago de Compostela, Santiago de Compostela; and ||Department of Neurology, University Hospital Lucus Augusti, Lugo, Spain*

Objective: Impaired balance in patients with Parkinson's disease (PD) leads to loss of balance and frequent falls. Computerized dynamic posturography allows the assessment of stance tasks whereas mobile posturography analyzes the balance in free-field conditions, where falls among PD patients commonly occur (e.g. sitting down or standing up). The aim of the present study is to assess postural stability in PD patients with both techniques.
Study Design: Prospective study.
Setting: University Hospitals, ambulatory care (outpatient clinic).
Patients: Thirty-three patients diagnosed with idiopathic PD.
Intervention: Balance assessment.
Main Outcome Measures: Dizziness handicap inventory (DHI), activities-specific balance confidence scale (ABC), composite score of sensory organization test (SOT), results of free-field body sway analysis (standard balance deficit test (SBDT)), or geriatric SBDT.
Results: PD patients showed a significantly higher sway in the roll direction in almost all of the SBDT conditions. Also, pathological sway compared with normative values was more prominent in complex tasks. There is a significant correlation between the different objective variables of the postural study (SOT and SBDT) and the ABC, but not with the DHI. Finally, the percentage of PD patients with a pathological score in SOT-composite score was 54.5% whereas in SBDT-composite score it was significantly higher (93.9%).
Conclusion: Mobile posturography is more accurate in depicting the reality of balance impairment in PD patients than platform posturography. Also, ABC relates better than DHI to the significant psychological consequences of balance impairments. An increased lateral trunk sway seems to be a key factor of postural instability in PD patients. **Key Words:** ABC—DHI—Mobile posturography—Parkinson's disease—Sensory organization test.

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Parkinson's disease (PD) is one of the most prevalent neurodegenerative diseases (1). Impaired balance in PD patients constitutes a serious handicap because it originates a high number of falls which are the main cause of hospitalization (2,3). Specifically, more than half of those patients experience falls (3,4).

The economic costs resulting from falls are considerable, because with some frequency they produce hip fractures in patients with PD. This type of fracture is so common because of the impaired protective reflexes of the arms which remain adducted against the trunk when falls occur, leaving the hip unprotected and exposed to a fracture (5).

Falls also entail significant psychological and social consequences, since after falls occur, patients lose confidence in themselves and restrict their physical activity from fear of falling again (6).

Furthermore, it is a well-known fact that pharmacological treatment does not decisively improve balance and gait impairments in PD patients (7). The same holds true for surgical measures (8). However, rehabilitation may be an effective way to improve postural stability (9–12).

Our earlier studies with computerized dynamic posturography (CDP) on a force platform have shown that PD patients suffer balance disorders basically because of

Address correspondence and reprint requests to Marcos Rossi-Izquierdo, Ph.D., Department of Otolaryngology, University Hospital Lucus Augusti, Calle Dr. Ulises Romero, 1, 27003 Lugo, Spain; E-mail: Marcos_Rossi@hotmail.com
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deficient processing of visual and vestibular inputs compared with healthy age-matched controls (13). In fact, a specifically deficient processing of vestibular information seems to be a key risk factor of falls in PD patients (14). But the deterioration of vestibular information processing does not depend on the stage of the disease (13).

Currently, mobile posturography (e.g. Vertiguard) allows assessment of balance in free-field conditions, where falls among PD patients commonly occur (e.g. sitting down or standing up). The aim of the present study is to assess postural stability in PD patients with platform and mobile posturography.

METHODS

Patients

Thirty-three patients diagnosed with idiopathic PD were categorized according to criteria established by Gelb et al. (15). The patients (22 males and 11 females) had an average age of 70.2 ± 1.6 standard error of mean (SE) years. Their mean distribution according to Hoehn & Yahr stage (16) was 2.1 ± 0.36 (SE). Each participant gave their informed consent to participate in the study in accordance with the Declaration of Helsinki. All procedures were approved by the Institutional Review Board.

We excluded all subjects who used a wheelchair or had additional neurological deficits. None of the patients had a history of peripheral vestibular disease and oto-neurological examination was normal (including absence of spontaneous or induced nystagmus by a head-shaking test and absence of saccadic movements by the Head-Impulse-Test). Also none of the patients had dementia and the score in the Mini-Mental test (17) was 25 points or greater.

During the study, all patients took their usual medication for PD and were tested and trained in their ''on'' state.

Assessments

Dizziness handicap inventory (DHI) (validated Spanish version [18] or German version [19]). This questionnaire characterizes disability resulting from balance impairment. It helps to quantify how dizziness affects the individual's quality of life. Maximum score (representing the greatest disability) is 100.

Activities-specific balance confidence scale (ABC): in 16 activities, the patient describes his or her level of confidence in performing activities without losing balance. An ABC score of 0% would indicate ''no confidence,'' 100% ''complete confidence'' (20).

Composite score of sensory organization test (SOT) of CDP (21). It is a well-established score designed to separate a somatosensory, visual, and vestibular input to overall postural stability through measurement of balance parameters in a CDP system (Smart Balance Master, Neurocom, Clackmas, OR, U.S.A.). Measurements are taken during three replicate 20-second runs under each of the following six sensory conditions: fixed surface, fixed visual surround, eyes open, fixed surface, eyes closed, fixed surface, moving visual surround, eyes open, tilting surface, fixed visual surround, eyes open, tilting surface, eyes closed, tilting surface, moving visual surround, eyes open. Composite score (0–100%) is the weighted average of the scores of all sensory conditions. Patients were classified as pathologic or normal based on the inbuilt age-dependent normative data.

Results of free-field body sway analysis (Standard Balance Deficit Test [SBDT] or geriatric SBDT). Patients were assessed with a body sway analysis (mobile posturography) by using the diagnostic tool of the Vertiguard device (Octocure GmbH, Metazinge, Germany) during 14 different everyday life stance and gait conditions (results were compared with inbuilt age- and sex-related normative values [22]).

This body-worn device is fixed on a belt and records body sway in the roll (lateral) and pitch (antero-posterior) planes respectively close to the center of body mass (COM) under well-defined sensorimotor conditions. In this way, trunk sway is measured by gyrometers at the hip whereas the subjects are asked to carry out the standard balance deficit test (SBDT) (22). The 27 elderly subjects (over 59 years) performed the geriatric version of the SBDT (gSBDT) while 6 patients performed the SBDT.

The SBDT consisted of the following tasks:

- standing on two legs with eyes open/closed,
- standing on one leg with eyes open/closed,
- eight tandem steps (one foot in front of the other) with eyes open,
- standing with two legs on a foam support surface (height 10 cm; density 25 kg/m^3) with eyes open/closed,
- standing on one leg on a foam support surface,
- eight tandem steps on a foam support surface,
- walking 3 m while rotating the head,
- walking 3 m while vertically pitching the head in rhythm,
- walking 3 m forward with eyes open/closed,
- walking over four barriers (height 26 cm with an interbarrier distance of 1 m).

The following tasks were skipped in gSBDT: standing on one leg with eyes closed and standing on one leg on a foam support surface.

Tasks ''stand up'' and ''sit down'' were added as the last two conditions of gSBDT version. Measurement time was 20 seconds for all stance tasks and as long as required for gait tasks.

The variables analyzed were:

a) Mean value of body sway in roll and pitch plane of SBDT/gSBDT.
b) The SBDT composite score (risk-of-falling indicator). This value was calculated as the sum of ratios of all tested examinations in SBDT/gSBDT to their age and sex-related normal values in pitch and roll (22).

Statistical Analysis

The sway in pitch and roll direction as well as the stability scores during different SOT conditions were compared by the t test for dependent samples or the Wilcoxon's test (depending on data distribution). Relationships between variables were investigated by calculating Pearson correlation coefficients (normal data distribution). A Bonferroni alpha correction was applied for multiple comparisons. Level of significance in all tests applied was $p < 0.05$.

RESULTS

PD patients showed a significantly higher sway in the roll direction in almost all of the SBDT conditions

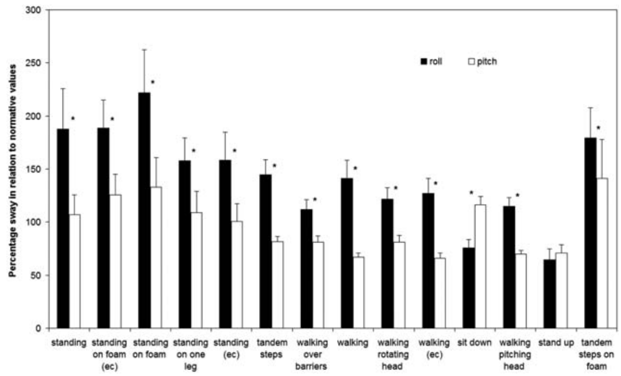

FIG. 1. Percentage sway in roll and pitch direction in relation to normative values in the SBDT condition (or g-SBDT in the elderly). The statistically significant differences are marked with an *asterisk*. *Error bars* represent the standard error of mean. SBDT indicates standard balance deficit test.

(except for sitting down and standing up) than in the pitch direction (Fig. 1). Also, pathological sway compared with normative values was more prominent in complex tasks like standing or tandem steps on foam, both in roll and pitch plane (Fig. 2A and B).

The ranking of SBDT conditions in relation to the proportion of pathological results in roll direction and pitch direction is summarized in Figure 3A and B. The number of SBDT conditions with pathological sway was higher in roll plane, and tandem steps on foam was the most pathological task in both planes.

Figure 4 shows the score of all SOT conditions. The mean stability score was significantly higher in standing tasks with a fixed surface (conditions 1–3) compared with all conditions with a tilted surface (conditions 4–6).

Furthermore, there is a significant correlation between the different objective variables of the postural study and the ABC (ABC-SBDT $r = -0.55$, $p = 0.002$; ABC-SOT

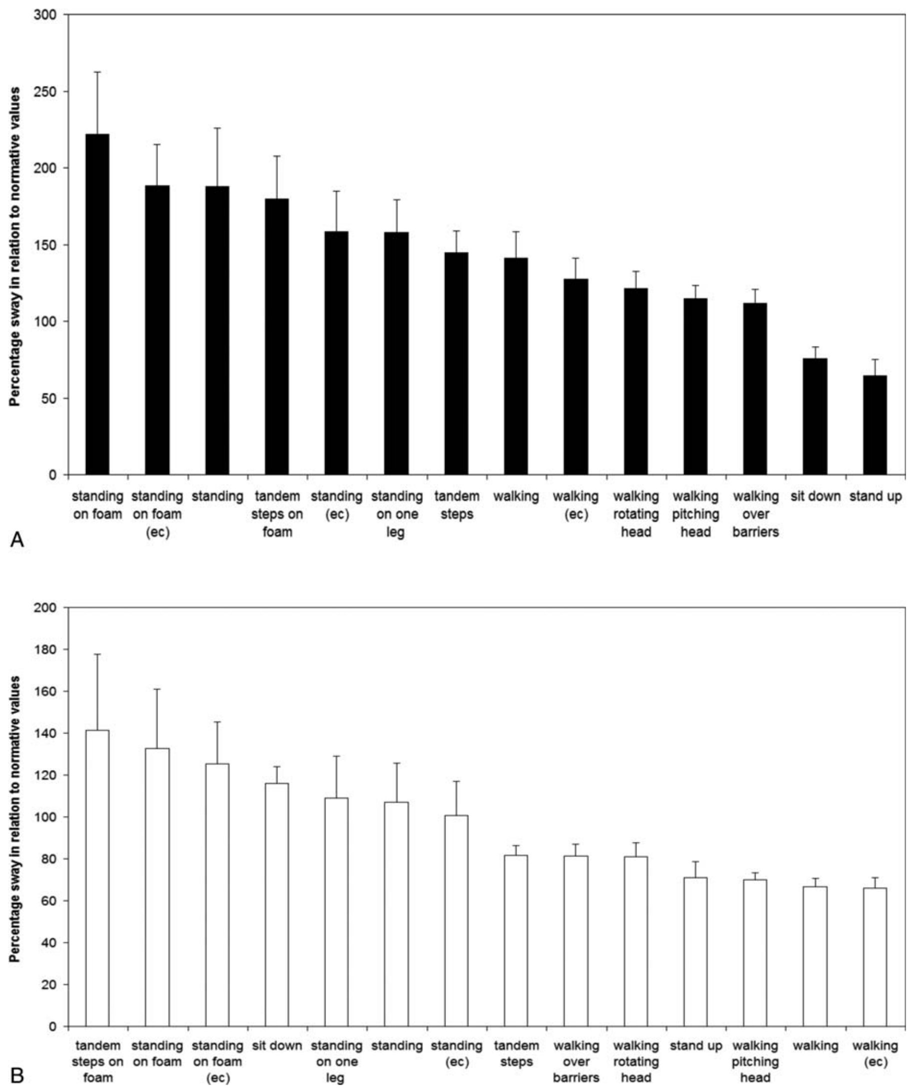

FIG. 2. Ranking of SBDT conditions (or g-SBDT in the elderly) in relation to the roll-sway (*A*) and pitch-sway (*B*). *Error bars* represent the standard error of mean.

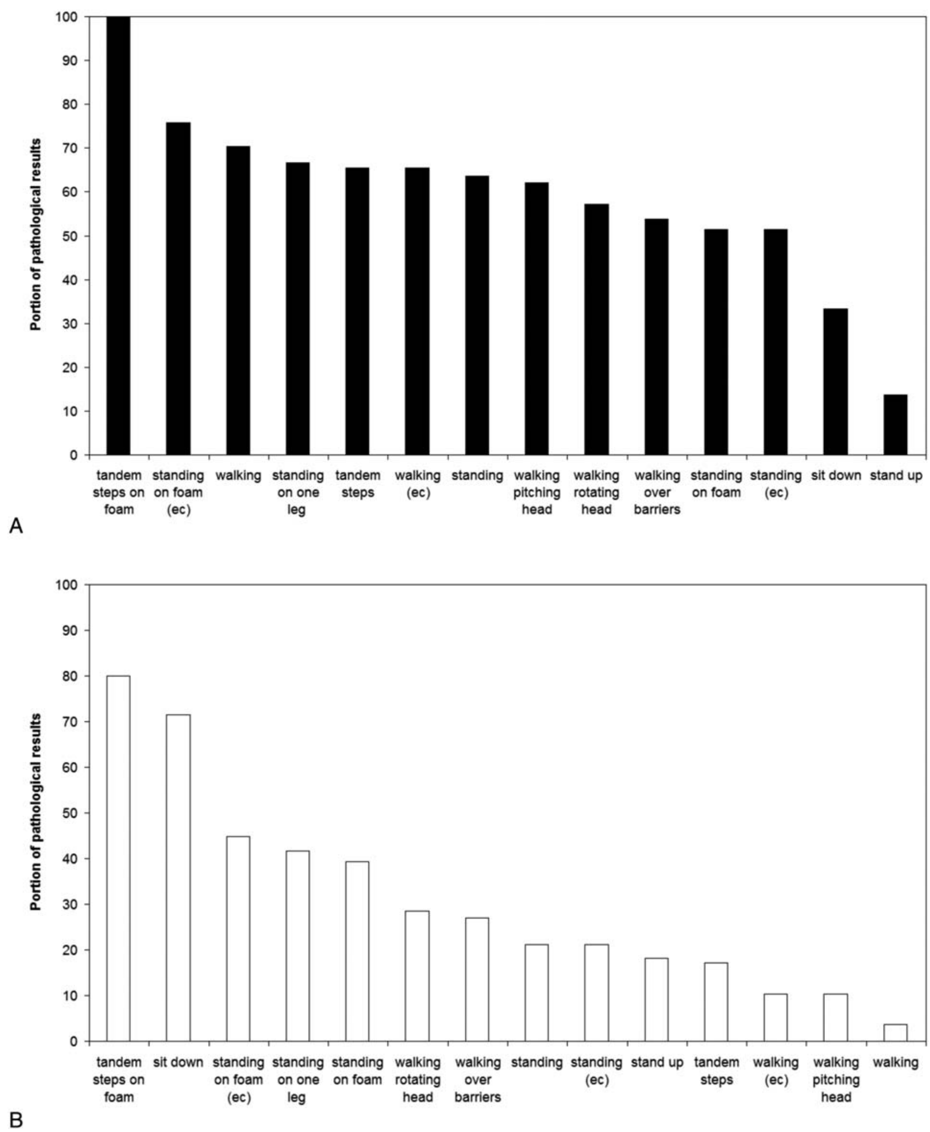

FIG. 3. Ranking of SBDT conditions (or g-SBDT in the elderly) in relation to the proportion of pathological results in roll direction (*A*) and pitch direction (*B*).

$r = 0.41, p = 0.03$; Pearson correlation used in both tests), but not with the DHI ($p > 0.05$, Pearson correlation).

Finally, the percentage of PD patients with a pathological score (sensitivity) in the SOT was 54.5% whereas in the SBDT it was significantly higher (93.9%).

DISCUSSION

Mobile posturography allows assessment of balance at the COM in daily-life conditions, where falls among PD patients commonly occur, whereas CDP with the SOT has the disadvantage that it only measures the ability to perform volitional, quiet stance during a series of six specific conditions on a force platform. Hence, mobile posturography can be expected to better depict the reality of balance impairment in our patients. In fact, our results in PD patients show that it correlates better with their impaired balance.

Since balance disorders do cause falls in PD, a correlation can be expected between posturography scores and ABC (which measures their confidence in performing activities without losing balance). No such correlation was observed with DHI, thus leading us to think that ABC reflects better the significant psychological consequences of balance impairment.

Our earlier postural study showed that among PD patients, lateral sway in the CDP tests correlates with the composite score, and is accordingly a more sensitive measure of fall risk than antero-posterior sway (13). Other studies have shown reduced lateral stability in PD patients (23) or an increase in mediolateral postural sway when compared with age-matched controls (24,25). Also PD subjects showed significantly more postural

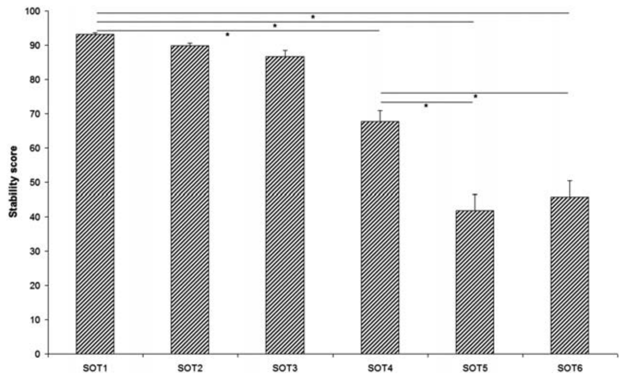

FIG. 4. Scores of the conditions of the SOT of the CDP. The statistically significant differences are marked with an *asterisk*. *Error bars* represent the standard error of mean. CDP indicates computerized dynamic posturography; SOT, sensory organization test.

instability and falls than age-matched control subjects when stepping was required for postural correction in response to lateral disequilibrium (26). Interestingly, PD patients in the present study also showed a significantly higher sway in the lateral (roll) direction in almost all of the SBDT conditions. Maybe, the rigid movements of PD patients during walking tasks (increased leg stiffness) lead in turn to an increased lateral sway. This is in contrast to other patient groups such as those with otolith disorders (27). Hence, the increased lateral trunk sway seems to be a key factor of postural instability in PD patients.

This, however, does not hold true when patients change their base of support, and instability is caused by a different mechanism. An accurate control of COM position is crucial to controlling the rise movement, as well as to maintain postural stability. If the COM is not moved sufficiently forward or if the COM is moved too far forward, the patient will either fall back into the chair or fall forward. Previous studies have reported that falls in transfers activities such as sit to stand represents between 15 and 21% of all falls (28,29).

Falls in PD mostly occurs during dynamic situations such as at gait initiation, tripping, or slipping while walking, stops and turns and while reaching out but rarely while standing quietly (28). Our results are consistent with these facts because the proportion of pathological results (compared with normative values) is lower in simple tasks like standing on two legs (eyes open/eyes closed). On the other hand, standing or tandem steps on a foam support surface in the SBDT or conditions 4 to 6 of SOT, show a more prominent pathological sway. PD patients during such tasks (standing or walking on a foam or mobile surface) cannot rely on somatosensory function and must use their vestibular or visual inputs. So it could be assumed that another crucial point of their instability is the integration of multimodal sensory input information as it has been hypothesized in a previous work (30).

On the other hand, the previous study has shown that postural instability in PD patients also affects reactive postural adjustments to external perturbations and anticipatory postural adjustments, besides balance during quiet stance and dynamic balance (31). However, further studies are needed to clearly identify and classify the different sources of postural instability in those patients.

Since rehabilitation is an effective way to improve their balance impairment (9–12), when designing a rehabilitation protocol we should focus more on complex tasks and lateral sway.

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