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RESEARCH ARTICLE

STABILOMETRIC ANALYSIS IN INDIVIDUALS WITH PARKINSON`S DISEASE

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ABSTRACT

Background: Parkinson's disease (PD) is a neurodegenerative disorder related mainly to the progressive loss of dopaminergic neurons in the substantia nigra pars compacta, a structure of the basal ganglia.

Objective: To analyze quantitatively the changes in postural stability and static balance in patients with PD. Methods: The sample was comprised of participants with a clinical diagnosis of idiopathic PD, and healthy participants. The participants remained in static position on the force platform. Data were obtained with open and closed eyes. The following parameters related to the body, right foot and left foot were used as main variables: 1) Area of influence of the sway (COP-Center of Pressure), 2) Antero-posterior sway (AP COP), 3) Latero-lateral sway (LL COP), 4) Average speed sway (*v*) of COP AP and LL.

Results: 34 volunteers underwent into two groups: (1) Parkinson Group (PG: 17 idiopathic PD-patients, age: 64.11±10.70), and Control Group (CG: 17 healthy controls, 60.47±8.53 years old). Without the visual feedback, PD-patients showed significant differences between healthy controls: COP of the body (p=0.004) and right foot(p=0.02); the sway of AP COP (p=0.009), right foot (p=0.03) and left foot (p=0.02) AP COP; *v*of the body AP COP (p=0.02), right foot (p=0.03) and left foot (p=0.01) *v* AP COP; sway of LL COP (p=0.01) and right foot (p=0.05) LL COP; *v* LL COP (p=0.01).

Conclusion: The sway of center of pression in PD-patients showed worse when compared with healthy controls, wich may explain the greater probability to imbalances and falls in these people.

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INTRODUCTION

Parkinson`s Disease (PD) is a neurodegenerative disorder of unknown cause. PD is related mainly to the progressive loss of dopaminergic neurons in the substantia nigra pars compacta, a brainstem structure belonging to the basal ganglia (Lang and Lozano, 1998). About 1% to 2% of the population over age 65 develops PD, this prevalence increases to 3% to 5% in patients with 85 years or older. Thus, it becomes more common in countries with high rates of populational longevity (Van Den Eeden *et al*., 2003) the diagnosis of PD is based on the presence of a bradikinetic stiff syndrome, asymmetric starting, resting tremor, with a good and sustained response to levodopa. Furthermore, postural instability is characterized by abnormalities related to posture as anterior postural tilt, semiflexion of elbows and knees associated to absence of postural reflexes, festination gait and *freezing* (sudden akinesia) are also considered markers of disease (Fahn, 2003; Halliday, 2007). Usually, postural instability occurs in the later stages of the disease and it represents a highly disabling symptom that difficult treatment, which interferes in the ability to maintain balance and predisposes imbalances and

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unexpected falls in PD patients (Marchese *et al*., 2003). These falls cause devastating consequences and are accompanied by pain, reduced mobility and unacceptably high levels of caregiver stress. Fear of falling is also higher in PD than in healthy subjects (Adkin *et al*., 2003).The maintenance of postural balance is the result of a complex mechanism, which requires sensory information from receptors located in various structures of body and coordination of motor recruitment patterns. The muscular, tendon and joint proprioceptive sensory information are extremaly important to control and postural balance to the feedback of limb position regarding other members, body and environment (Barnett *et al*., 2003). However, the visual information has greater importance for postural control and balance, providing anticipatory information (feed forward) on body position and tasks to be executed later (Duarte *et al*., 2002; Konczak *et al*., 2009). In a human body apparently immobile, in orthostasis, the body presents continuous micromovements, even imperceptible. These movements occur in both the sagittal plane (anterior-posterior) as in the frontal plane (side-to-side). These are physiological compensatory movements of the center of gravity to ensure maintenance of posture through a complex mechanism of the central nervous system (CNS). The amplitude and frequency of these oscillations vary from subject to subject, according to their normal or pathological condition (Terekhov, 1975).

Stabilometry is a method of measuring postural stability or balance in individuals, and consists of transformations of mechanical oscillations of physiological center of gravity of the subject to electrical signs, which are amplified, recorded and analyzed (Terekhov, 1975; Ebersbach, 2011).The frequency, duration, average and maximum amplitudes of the oscillations and coefficients reflect the influence of vision in patients with different neurological diseases through the values in healthy people. The method is highly sensitive, reliable, quick and simple to use without damage and discomfort and allows to evaluate a large number of subjects in short time (Terekhov, 1975).The assessment of imbalances is relevant for staging, prognosis and treatment of disease, since the imbalance and falls are major causes of disability in advanced stages of PD (Ebersbach, 2011).

In clinical practice, the assessment of postural control is based on neurological examination, including the Romberg test, pull test and gait examination, but all of them are quantitative methods and techniques for the measurement of postural control in geriatric assessment, whichwere not established in the clinical routine (Ickenstein *et al*., 2012).Given the above and in view of the neuromotor changes in PD patients, especially those related to static balance and postural stability, the purpose of this study was to analyze quantitatively the changes in postural stability and static balance in patients with PD compared with healthy subjects.Specifically, the objective was to assess anteroposterior (AP) and lateral-lateral (LL)postural sway, the area of influence in the oscillation of the center of pressure (COP) and average speed (velocity *v*) in PD-patients; to analyze changes in these variables from the deprivation of visual information; and to compare changes in AP and LL postural sway and the area of influence of the COP in patients with PD and healthy people.

METHODS

Subjects of the study

The sample was obtained for convenience and composed to 17 subjects with idiopathic PD (2 to 3 Hoehn&Yahr staging), with even or over one year length, treated with levodopa and stable concerning anti-parkinsonism medication; and to 15 healthy people, without neurologic or osteomioarticular complaint. The inclusion criteria for PD patients were: presence of motor fluctuation; convenctional antiparkinsonism therapy, excluding amantadine, clozapine, deep brain stimulation, palidotomy and previous thalamotomy.The following inclusion criteria for PD patients and healthy subjects were: both genders, age between 50 and 80 years old; without psychiatric disturbances, cognitive decline or dementia that influence process of communication; abscense of recent or not solved muscleskeletal disorder, vestibular, neuromuscular or cardiopulmonary which affect the mobility or roam capability; ability to keep standing for 10 minutes; capacity of walking independently, with or without auxiliar devices; without physiotherapeutic treatment (Ickenstein *et al*., 2012).

Ethic Aspects

The present study was approved of Ethic Research with Human Committee, at Federal University of Sergipe, by protocol number CAAE 0040.0.107.000-10, and subjects signed informed consent beforestarting collection data.

Design of the study

This study is cross observational. The subjects were recruted in Neurology Ambulatory of College Hospital at Federal University of Sergipe, during one year.

Stabilometry Analysis

Eletronic baropodometer was used for data collection through individual force platform (ANC, FootWork Pro 1.1.3.0 version, with 2.704 captors and active surface of 400 x 400 mm, 150Hz frequency of picture collection).Subjects remained with barefoot on force platform, feet apart lightly and upper limbs along the body, fixed eyes on a certain point, one meter away from the platform, on the horizontal line.Watches, bracelets, earrings, or other objects were removed to not interfere the analysis. Furthermore, the position of the feet on force platform were the same throught all of the data collection, since sway was evaluated in a static way, only. Three samples were collected with eyes open, and then three other with eyes closed, in order to obtain a final average in each situation. The sign of force platform was converted analogic to digital (12 bit), in 150Hz and stored for off-line processing with Footwork Pro® software. The data were filtered in 7,5Hz. Related parameters of the body, left and right feet, computed during 10 seconds, were: 1) Influence area of Center of Pressure (COP) (mm^2): ellipse surface cover 90% computed points of COP; 2) Sway of COP in antero-posterior way (AP) (mm): displacement measure of COP in sagittal plane (y axis); 3) Sway of COP in latero-lateral way (LL) (mm): displacement measure of COP in frontal plane (x axis)[14]; 4) Average speed (velocity) of COP sway in AP (*v* AP) and LL (*v* LL) way (m/s): speed of pressure point on platform force (Armand *et al*., 2009).

Statistical Analysis

The collected data were transported initialy to spread sheet of Excel for Windows program 2010, and afterward to SPSS program, 17 version, for following analysis: (a) descriptive: with tables of frequency, position measures (average, median, minimum and maximum) and dispersion (standard deviation and error standard of mean); (b)normality test to identify whether the data were parametric or nonparametric; (c) comparison: t test for independent measures. Data with p ≤ 0.05 were considered statistically significant.

RESULTS

The groups had the following characteristics: (1) Parkinson Group, composed of 17 subjects (10 men and 7 women) with a mean age of 64.11±10.7 years, diagnosed with idiopathic PD, lasting less than one year , and (2) control group consisted of 15 healthy subjects (9 women and 6 men) with a mean age of 60.47 ± 8.53 years, without neurological and musculoskeletal complaints. Other demographic data and their respective P values are shown in Table 1.Patients affected by PD reported frequent falls or stumbles, and of the circumstances presented, are falling out of bed during sleep, in the bathroom and stumbles in objects in the streets.Regarding the Hoehn and Yahr scale, which defines the various stages of PD: 3 subjects were classified in stage 2 (bilateral disease, without impairment of balance), 6 in stage 2.5 (mild bilateral disease, with recovery in test retropulsion) and 8 in stage 3 (mild to moderate disease, bilateral, some postural instability, physically independent).

Table 1. Characteristics of sample in Parkinson Group (PG) and Control Group (CG)

Baseline Data	Parkinson	Control	P
	N=17	N=17	
Age (years)	64.1±2.61	60.47±2.00	0.42
Weight (kg)	65.54±2.79	68.67±3.20	0.47
Height (cm)	157.24±0.17	159.81±0.19	0.31
BMI	26.54±0.81	26.96±1.30	0.79
MMSE	24.83±0.69	25.06±0.52	0.88
BDI	13.55±1.88	13.62±1.37	0.79

BMI: Body mass index. Mean±SD and P value. T test for independentvariables. Without significance between groups.

Influence area of COP (mm^2)

Regard to the influence area of the COP, when the subjects were assessed with eyes open, there was no difference between groups. However, with the absence of visual feedback, the influence area of the COP in the body (Figure 1A) and right foot (Figure 1B) was significantly higher in PG than in CG. The area of the body showed a mean of 49.59±12.02 mm^2 for the PG, and 19.31±3.51 mm^2 for the control group (P = 0.04) and for the right foot, the PG, the average was 29.46±6.48 mm^2, and the CG was 11.19±1.25 mm^2 (P = 0.02), with closed eyes.

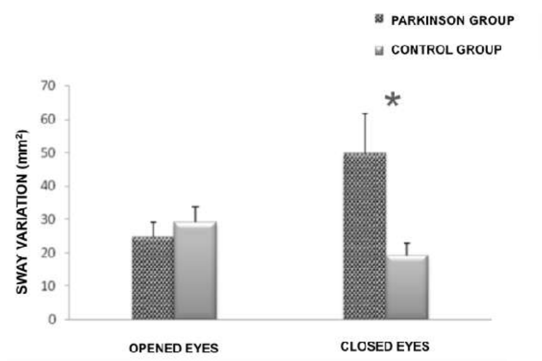

Figure 1A. Influence area of COP, during quiet stancein Parkinson Group and Control Group. Mean±SD, T test, *p=0.04

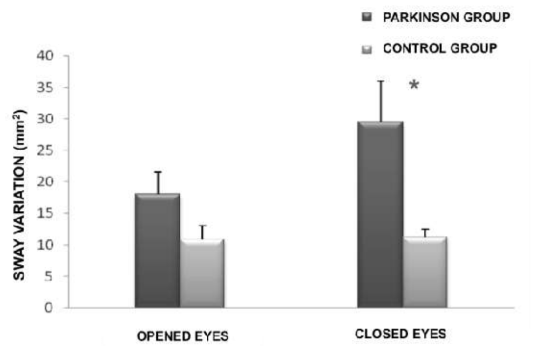

Figure 1B. Influence área of COP in right foot, during quiet stance in Parkinson Group and Control Group. Mean±SD, T Test, *P= 0.02.

Sway of COP AP (mm) and Velocity AP (mm/s)

The oscillation of the COP in the AP direction relative to the body, right foot and left foot (Figures 2A, 2B and 2C), as well as the speed of the COP AP (Figures 3A, 3B and 3C). PG was significantly higher than in the CG where evaluated from the deprivation of visual information. When evaluated with open eyes, there was no difference between groups.For PG, the average oscillation AP (body) was 28.95±4.51 mm^2, and 16.76±1.12 mm^2 for the control group (P = 0.009). Regarding the right foot, the PG had an average of 33.90±5.40 mm and 20.83±1.12 CG mm (P = 0.03) and related to the left foot, the average oscillation in PG was 31.23±4.83 mm, whereas in CG was 17.93±1.54 mm (p = 0.02).

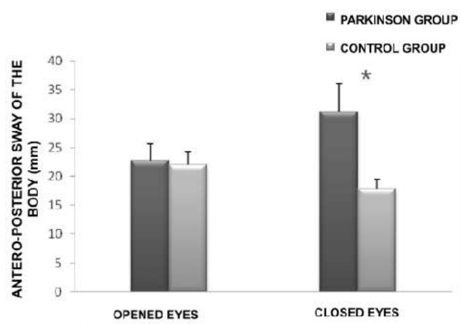

Figure 2A. Antero-posterior sway of the body, during quiet stance in Parkinson Group and Control Group. Mean±SD, T test, *P= 0.009

Figure 2B. Antero-posterior sway of the right foot, during quiet stance in Parkinson Group and Control Group. Mean±SD, T test, *P= 0.03

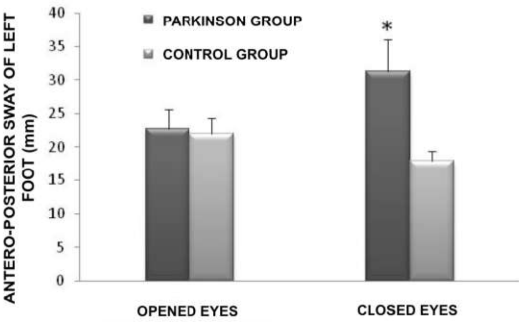

Figura 2C. Antero-posterior sway of the left foot, during quiet stance in Parkinson Group and Control Group. Mean±SD, T test, *P= 0.02

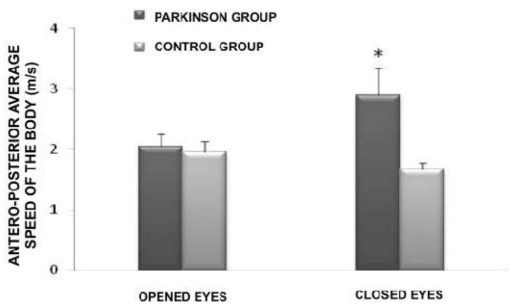

Figure 3A. Antero-posterior average speed of the body, during quiet stance in Parkinson Group and Control Group. Mean±SD, T test, *P= 0.02

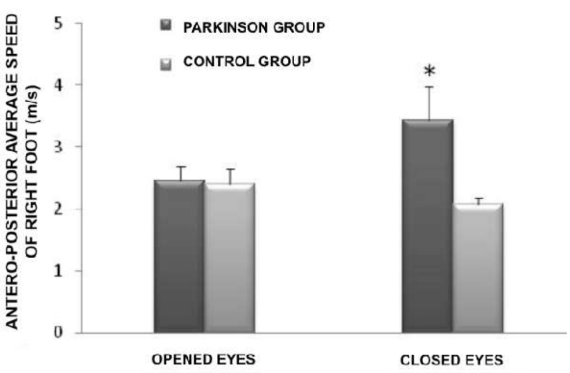

Figure 3B. Antero-posterior average speed of right foot during quiet stance in Parkinson Group and Control Group. Mean±SD, T test, *P=0.03

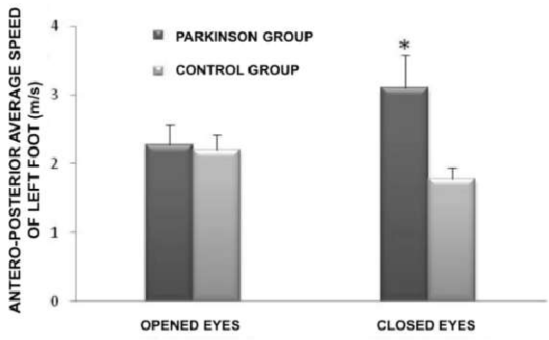

Figure 3C. Antero-posterior average speed of left foot during quiet stance in Parkinson Group and Control Group. Mean±SD, T test, *P = 0.01

The AP Vm (body) in the PG had a mean of 2.89±.45 mm/s and 1.67±.11 CG mm/s (P = 0.02). The AP velocity (right foot) was 3.44±.55 mm/s, and 2.08±.11 mm/s in the control group (P = 0.03). What about the left foot, was 3.1±.4 mm/s in PG, and 1.79±.15 mm/s in the control group (P = 0.01).

Sway ofCOP LL (mm) and Velocity LL (mm/s)

The results showed diferences between groups in LL sway with closed eyes, only. PG presented more LL sway in the body and right foot than CG. The LL average speed of the body was also higher in PG, with closed eyes too. Regarding LL sway of the body (Figure 4A), in PG, the average was 23.83±4.02 mm for PG, and 13.28±1.61 for CG (P = 0.01), regarding right foot (Figure 4B), the average of PG was 13.28±3.40 mm, and CG 6.46± .51 mm (P = 0.05).The LL average speed of the body (Figure 5), PG showed 2.37± .40 mm/s and CG 1.32± .16 mm/s (P = 0.01).

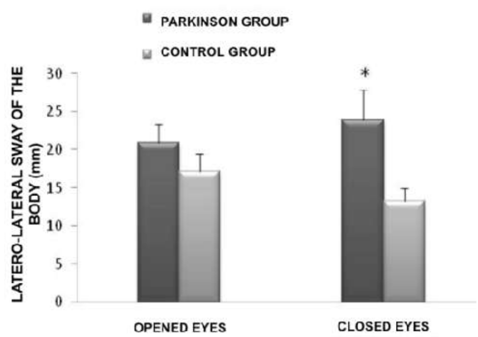

Figure 4A. Latero-lateral sway of the body, during quiet stance in Parkinson Group and Control Group. Mean±SD, T test, *P=0.01

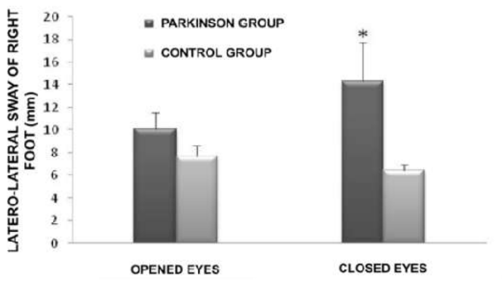

Figure 4B. Latero-lateral sway of right foot, during quiet stance in Parkinson Group and Control Group. Mean±SD, T test, *P=0.05

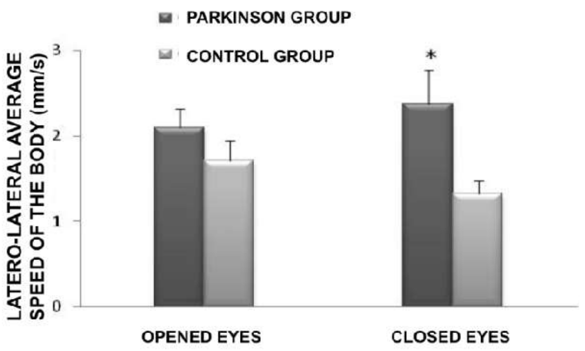

Figure 5. Latero-lateral average speed of the body, during quiet stance in Parkinson Group and Control Group. Mean±SD, T test, *P = 0.01

DISCUSSION

The stabilometric assessment in this study showed differences between PD patients and healthy control subjects when variables of COP sway were evaluated with closed eyes. Most variables of COP sway was significantly greater in all directions in the PG, showing that the visual system is a major contributor to the balance, as it provides information about the environment, location, direction and speed of movement of the body (Spirduso, 1995).Furthermore, the results demonstrated how the changes of visual system related to aging can reduce the ability to maintain balance and postural control, even in a static way, and especially when the person is affected by neuromotor disorders, such as Parkinson's disease.The results indicated that closed eyes measurement increased sway in AP way in both lower limbs and LL way in right lower limb, only. In the body, the oscillation in both directions were increased. These results were significantly different from healthy control group, which showed no increase in oscillation with the same test in either direction when removed visual feedback. According Bosek *et al* (?), a postural compensation mechanism is activated when the eyes are closed, and this mechanism is clearly impaired in PD.

According Adkin *et al* (2003), subjects with PD tend to have larger COP sway, because they present more postural instabillity. In addition, several different factors are involved which cause postural instability, among them, anxiety is related to the fear of falling.This factor may have been increased fluctuations in COP in individuals with PD in our study when the visual information were removed.Blaszczyk *et al*[17]related that the increase of corporal AP sway is result of tilted posture in PD. This present study showed increase in COP sway in AP and LL directions when eyes were closed. Furthermore, significant increases in mean speed of COP area in both directions were detected. For some authors (Horak *et al*., 1989; Blaszczyk *et al*., 1992; Blaszczyk *et al*., 1994), the tilted posture is considered one of the most efficient mechanisms to improve compensatory postural stability. Probably the AP sway as well as the speed of the AP oscillations increased as a strategy to compensate the increase of the LL sway, preventing a possible imbalance. Since the LL oscillation of the body increased probably due to the asymmetry of parkinsonian signs, as in PD, there is a side of the body more affected than other(Rocchi *et al*., 2006; Mitchell *et al*., 1995; Blaszczyk *et al*., 2007).

The COP is a distribution center of total force applied to a contact surface. It represents weighted average value of all pressures on the contact area of the surface. If one foot is on the ground, the COP is on the foot, if both feet are on the ground, the COP is between two feet, depending on the weight applied by each foot. The location of the COP on each foot is a direct reflection of the neural control of the muscles of the ankle. The increase activity of the plantar flexors move the COP in AP axis, and increase activity of inverters muscles moves COP laterally (Winter, 1995).

The LL sway increase in right foot may be related to the fact that most of PD-patients in this study have greater involvement of right hemisphere, then probably there was an increased activity of the inverter muscles in right ankle, which reflects the insecurity regarding weight-bearing in lower limb more affected by PD.Some authors(Maki *et al*., 1994; Maki *et al*., 1996; Laughton *et al*., 2004)believe that the increased lateral sway is associated with an increased risk of falling. Jancová (Jancová, 2008) claimed that loss balance in lateral directions is very difficult to retrieve because the discharged lower limb is on the opposite side, contrary to occurs in the AP direction, wherein a step forward or backward can correct the posture of the body.

As in this study, Blaszczyk *et al* (2007) also evaluated the postural instability in PD (Hoehn and Yahr 1-3). They studied the effects of the exclusion of visual feedback on the characteristics of the COP sway during quiet stance. After analyzing the data, the found resultsshowed the same way about that the vision system promotes direct influence on the COP displacement in PD-patients, which shows a different sensitivity to viewing conditions for each group.The postural stability is decreased in old people, especially when subjects were in a unstable platform or visual information was limited or distorted (Liaw *et al*., 2009). The deprivation of visual information increase COP area, especially in patients with a previous history of falls, demonstrating that the fear of falling have great influence in stabilometric analysis (Marchese *et al*., 2003).Thus, characteristic postural instability of PD associated with deprivation of visual information can lead to greater body imbalance and consequent trips and falls, influencing the reduced quality of life.

Conclusion

Based on these results, we can say that the COP area, the AP and LL oscillations and mean speed were altered in PD-patients compared to healthy subjects, especially with deprivation of visual information, which may explain the higher propensity to imbalance and falls, and consequently lesions in these population.Analysis of postural stability and static balance from stabilometry should become indispensable in routine clinical evaluation in patients affected by disorders of balance and postural stability, because changes in COP sway can aid in prognosis, and monitoring rehabilitation progress of these patients.The proposal is for an upcoming study, that analyse is carried out with a larger sample, and compare the variables of COP sway before and after physical therapy focused on balance and postural stability in patients with PD, and the fear of falling in these patients is measured before and after treatment, since this is a factor closely linked to the cause of postural instability.

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