Visual restriction and anterior-posterior body oscillations in Parkinson's disease

ORIGINAL ARTICLE

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ABSTRACT

With their vision restricted, sufferers of Parkinson's disease (PD) make few anticipatory and/or compensatory adjustments in their posture and the evidence of these adjustments is even less when the disease progresses and body oscillations are considered. **Objective:** The aim of this study was to demonstrate the effects of visual restriction on the anterior-posterior body oscillation angles in parkinsonian stance considering the early stages of this disease. **Method:** Ten elderly PD patients with Hoehn & Yahr (HY) stage 2 remained standing still for 30 seconds to measure the body oscillation angles with and without restricted vision. **Results:** Two-way ANOVA analyses with repeated measurements revealed the main effect of vision ($F_{(1,7)} = 8.931$, $p < 0.02$). **Conclusion:** The angles of the anterior-posterior body oscillations without visibility were greater than with visibility. They did not differ in correlation with the HY stages and visibility conditions interfered with the postural control regardless of the PD evolution stage.

Keywords: parkinson disease, posture, stereotypic movement disorder, vision disorders

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INTRODUCTION

The slow, progressive, dysfunction of basal nuclei, caused by the degeneration of nigrostriatal pathways in Parkinson's disease (PD), alters voluntary movement, postural control, and occasionally affects cognition.[1,2,3,4] A few of the main neuromuscular impairments in PD such as akinesia, hypokinesia, cogwheel rigidity, increased rigidity of trunk flexors, and a tendency to remain in fixed postures change one's capacity to stand erect.[1,3,5]

Knowing that balance deterioration is commonly present in PD,[6] in relation to postural instability, the most salient primary impairment in the elderly with this disease is the insufficient and slow production of the strength necessary to react to body disturbances, accompanied by inflexible, insufficient, and slow postural responses.[7,8]

In relation to postural responses, individuals with PD cannot make the appropriate anticipatory postural adjustments, which contributes little to minimizing changes to the center of mass stemming from movements, thus leading to a decline in the static balance control and falls.[1]

It is known that PD sufferers have increasing difficulty in performing self-started movements which compromises the motor system,[3] and which evolve through clinical stages of this disease.

It is difficult for the elderly to adjust the sensory and motor systems that control posture. In the specific case of the visual system, the effect that central and peripheral visual input has on the increased body oscillations of healthy elderly when compared to young adults has been observed in experimental situations with the discreet movements of a moving room.[9]

The contributions of visual input to bipedal postural control, in relation to spontaneous body oscillations under visually restricted conditions have been studied extensively,[10,11] however, in elderly people with PD, there is less scientific evidence.

In the case of visual restriction, few anticipatory and/or compensatory adjustments were observed among the elderly with PD,[12] however, the variation of the spontaneous body oscillation angles, taking into consideration the clinical stage of the PD evolution based on the Hoehn & Yahr scale (HY)[13] and visual restriction, have not been provided.

The pathogenesis of postural balance alteration in PD is poorly understood,[14] and considering that postural instability appears at the stage 3 in the HY,[13] but showing changes in the postural balance at the initial stages of the disease, it is pertinent to deepen the knowledge on the maintenance of almost static erect posture in conditions of visual restriction in PD sufferers who have balance alterations in the initial stages of the disease.

OBJECTIVE

In this context, the objective of this study was to demonstrate the effects of visual restriction on the anteroposterior body oscillation angles in the erect posture of PD patients, considering the initial clinical stages of the disease.

METHOD

The sample was composed of 10 individuals with PD, 5 females and 5 males over 60 years old, recruited in the city of Rio Claro, in the state of São Paulo. The study included elderly people with PD up to the HY stage 2, who had not suffered falls in the previous 12 months, with cognitive capacity preserved, and excluded those who presented dementia or who had other diseases that could compromise their postural balance. The Ethics Committee approved the study with the protocol number 4960.

A neurologist diagnosed the disease, a geriatric psychiatrist evaluated the evolution stage by the HY scale; then, to better characterize the sample, the degree of impairment was evaluated by the Unified Parkinson's Disease Rating Scale (UPDRS),[15] followed by the overall mental state, using the mini mental state exam (MMSE). The participants' characteristics are shown in Table 1.

Before data collection, each participant was informed on the objective of the experimental procedures of this study and, after they agreed, they signed a free and informed consent form.

Reflective markers, 15 mm in diameter, were positioned on the lateral malleolus and on the right hemibody clavicle process of each participant. The task consisted of standing still for 30 seconds under the eyes-open and eyes-closed conditions. Only one trial for each condition was analyzed. All the tests were applied with the participant under the effect of antiparkisonian medication.

The data collection was made by a digital camera at 60 Hz. The capture of images was made by a Pinnacle (model Studio DV, version 1.05.307) video card, coupled to a computer.

The bidimensional trajectories of the markers were obtained through kinemetric procedures, using Dvideo software.[16,17] The bidimensional space was calibrated using two plumb lines having six markers with known positions in relation to the *x* and *y* coordinates of the Cartesian system. The *y* axis was defined in the vertical, oriented upwards. The *x* axis was defined horizontally, oriented to the anterior direction of the participant, and orthogonal to the *y* axis.

For the bidimensional reconstruction of the images process, a test of accuracy[18] was done, whose value of 4.8 mm was acceptable in view of the magnitude of the movement analyzed, and its relation to the radius of the reflective markers. After the bidimensional reconstruction, a set of discrete data was obtained for the *x* and *y* coordinates of each marker as a function of time (*x(t)* and *y(t)*). The MATLAB 7.0® software was used for all the treatment procedures, analyses, and calculations of the kinematically dependent variables.

The second-order Butterworth filter, with a cut frequency of 5 Hz, was used to smooth out the data.[19] For the dependent variables, first the vector to represent the erect position of the participant at each instant of time during the task was calculated (equation 1). The absolute oscillation angle was defined as the angle formed between the erect position vector and the y axis vector of the reference system adopted (equation 2).

$$\textbf{(1)}\ vpe(i) = cla(i) - tor(i) \qquad \textbf{(2)}\ aoa(i) = \cos^{-1}\left(\frac{vpe(i) \bullet y}{\|vpe(i)\|\|y\|}\right) \times \frac{180}{\pi}$$

Thus, *epv(t)* was the erect position vector at that instant of time *t (t* = 1*, ..., n); aoa(t)* was the absolute oscillation angle; *cla(t)* and *ank(t)* were the *x* and *y* coordinates of the markers on the clavicle process and on the ankle, respectively: and the symbols ●, –, and ‖ ‖ represent, respectively, the operations of the dot product, subtraction, and vector norm in R^2. Consequently, to calculate the average angular amplitude of body oscillation, the *aoa* was used.

The absolute oscillation angles were normalized through the subtraction of the oscillation values average at each instant in time (equation 3), and in this way we can see the anterior and posterior tendency (in the anteroposterior direction), and the tendency to the right and to the left (in the medial lateral direction) of the body oscillations under the eyes-open and eyes-closed conditions.

$$\textbf{(3)}\ aoan(i) = aoa(i) - \left(\frac{1}{n} \times \sum_{i=1}^{n} aoa(i)\right)$$

Table 1. Characteristics of the participants

P	Gender	Age	HY	UPDRS Total	MMSE	Medication
A	M	74	1	25	29	Pramipexole, Biperiden
B	F	81	1	16	30	Selegiline
C	F	66	1	13	27	Pramipexole
D	F	60	2	47	29	Amantadine, Levodopa
E	M	75	1.5	33	24	Levodopa, Selegiline, Biperiden
G	M	69	1	29	29	Biperiden, Levodopa/Benserazide
H	M	60	1	28	28.5	Pramipexole
I	F	71	1.5	18	28	Levodopa/Benserazide
J	M	78	2	58	23	Levodopa/Benserazide
K	F	67	1	19	29	Pramipexole, Selegiline, Levodopa/Benserazide

P: Participant; M: Male; F: Female; Age (years); HY: Hoehn-Yahr; UPDRS: Unified Parkinson's Disease Rating Scale; MMSE: Mini mental state exam

The normality and homogeneity of the data with Shapiro-Wilk and Levene, respectively, was confirmed, so the data were compared by parametric statistics. Descriptive statistics (average and standard deviation) and two-way ANOVA were used, having as independent variables the conditions of vision and the clinical stage of the disease, with measurements repeated under the vision conditions, and with the anteroposterior oscillations as a dependent variable. For the statistical treatment of the data, the SPSS® software for Windows, version 10.0 was used, and the significance level adopted was $p < 0.05$.

RESULTS

The two-way ANOVA with repeated measurements did not show any main effect for the clinical stage of the disease ($F_{(2,7)} = 0.159$; $p > 0.05$), or interaction between the factors ($F_{(2,7)} = 2.231$; $p > 0.05$). However, the analysis showed a main effect for vision on the anteroposterior oscillations ($F_{(1,7)} = 8.931$; $p < 0.02$), with the anteroposterior body oscillation angles greater in the eyes-closed condition than in the eyes-open condition (Figures 1 and 2).

The average and standard deviation values of the anteroposterior body oscillation angles of the 10 participants in the eyes-open and eyes-closed conditions are shown in Table 2, and the anteroposterior body oscillation angles of one participant in the eyes-open and eyes-closed conditions are shown in Figure 3.

DISCUSSION

The purpose of the present study was to indicate the effects of visual restriction on the anteroposterior body oscillation angles of the almost static erect posture in the elderly with PD, considering the initial stages of the disease. In that sense, significant differences in the anteroposterior body oscillation angles between the two visual conditions were found; the angles increased when the eyes were closed as compared to when the eyes were open, consequently, the effect of visual restriction was observed in the almost static erect posture of the elderly with PD who participated in the study. However, the body oscillation angles of these elderly did not differ among themselves when the clinical evolution stage of the disease was considered.

Similar results in relation to the behavior of body oscillations have been reported elsewhere. In elderly people with PD, during the almost static erect posture task on a rigid surface and on a foam surface, the values of the trunk oscillation angular velocity on the anteroposterior axis were significantly greater without vision (eyes closed) than with vision (eyes open); thus, the effect of visual restriction became evident under these experimental conditions. In addition, it was reported that even under the effect of medication these elderly had poor control of their balance in the erect posture.[20]

The effect of visual restriction on increased body oscillation has been pointed out in different studies.[21-24] Nevertheless, there are controversies regarding increased anteroposterior body oscillations under visually restricted conditions when comparing between healthy elderly people and those with PD.[21,24-27]

In the present study, and without a comparison with healthy elderly having been made, the results confirmed that the visual restriction generated an increase in the anteroposterior body oscillation angles in elderly with PD.

Studies on PD have used different tools and calculations to measure the body oscillations on the anteroposterior axis.[12,20,24,28] In the case of this study, videogrammetry was used to measure the absolute angles of the body oscillations. It is possible that the use of different tools, calculations, and experimental procedures could partially justify the controversies among the evidence, when compared to the behavior of body oscillations, and more frequently, when observing the effects of visual input in the postural control of elderly with PD.

The increase of the anteroposterior body oscillation angles with visual restriction can be partly explained by sensory reweighting. When a sensory channel is disturbed and changes the amount of information available,

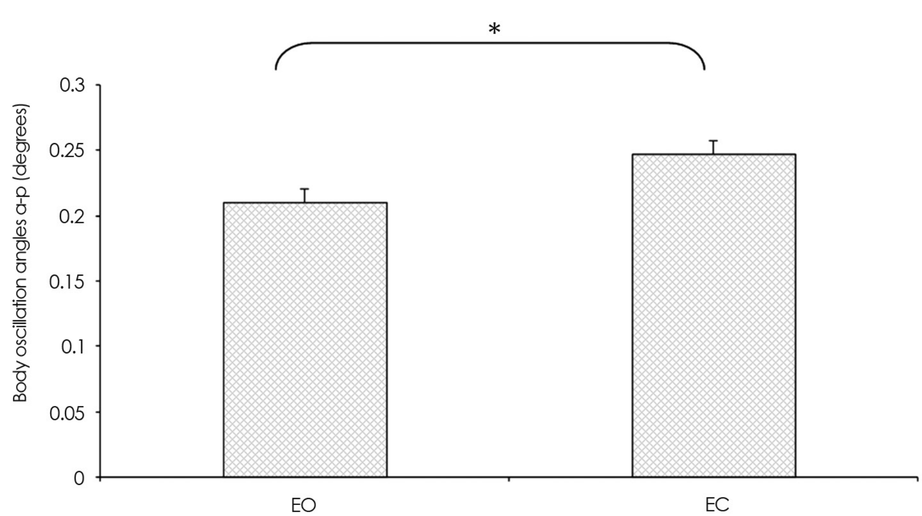

Figure 1. Average and standard deviation of the anteroposterior body oscillation angles (ap) in degrees, for the elderly with Parkinson's disease in the eyes-open condition (EO) and eyes-closed condition (EC)

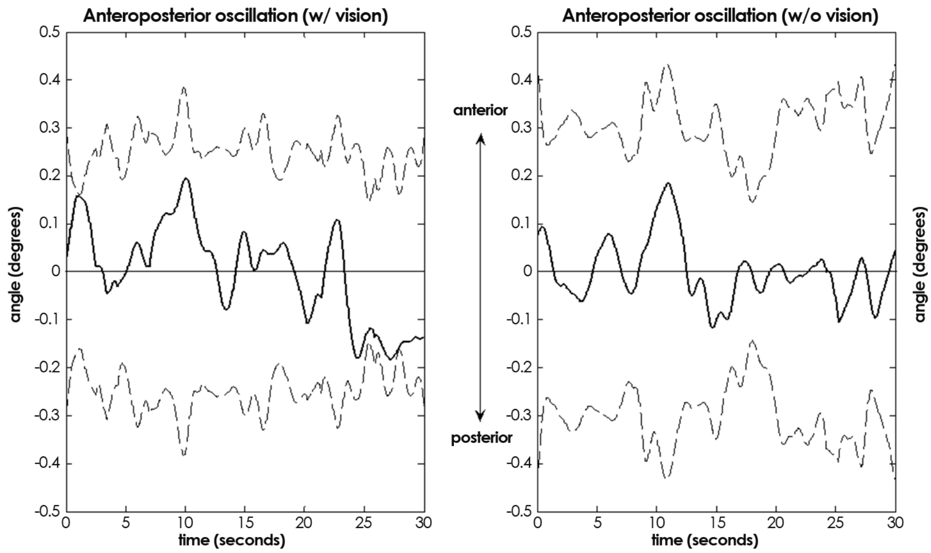

Figure 2. Representation of the average and standard deviation of the anteroposterior body oscillation angles of the 10 participants in the eyes -open and eyes-closed conditions

the reweighting of sensory signals responds to the changes in the environment and to the amplitude of the stimulus.[29] Specifically, when the elderly are without vision (eyes closed), the weight of the visual information is reduced dramatically, and distributed among their somatosensory and vestibular channels to control their posture.

To justify the results, the role of the visual system can also be considered in the perfecting of the body oscillations and orientation of the body in space. The availability of vision provides accurate information for postural orientation, and helps to refine postural balance control.[30] Consequently, not having vision available can increase the angles of the body oscillations.

In the posture and locomotion tasks, the body trusts the visual system; however, it is known that people can have a greater or lesser degree of dependence on visual input to control their posture.[31,32] Thus, the increase in the anteroposterior body oscillation angles with visual restriction can be understood also by the greater degree of dependence on visual input to control the posture of the people with PD, who participated in this study.

However, the increase in stochastic muscular activity, under conditions of visual restriction was observed in elderly people with PD as well as in healthy elderly, when compared to young adults; nevertheless, an absence of compensatory postural adjustments were observed in elderly people with PD. Consequently, the increase of stochastic muscular activity was considered as a specific indicator of age. However, the absence of compensatory postural adjustments was considered a specific indicator of the disease's progression.[12] In that sense, we expected to find an effect of the clinical stage of the disease at the initial levels, as measured by the HY scale, on the anteroposterior body oscillation angles under the two visual conditions. However, it was observed that the body oscillation angles with and without vision were not influenced during the initial clinical stages of the disease.

The absence of any correlation between the HY scale and the displacement amplitude of the CP (center of pressure) was recently reported in 55 people with PD in the first three clinical stages, on the anteroposterior axis with eyes open and eyes closed.[21] Considering that, in the present study, the size of the sample and the body oscillation variable were different, the absence of effect from the clinical stage of the disease at the initial levels may be due to the absence of any relationship between the HY scale and body oscillation.

To re-state, as of stage 3 of the HY, postural instability and deterioration of the balance reactions are more evident,[14,33] it could be argued that the absence of effect of the initial clinical stages of the disease on body oscillations in this study was due to the first 2 stages of the HY, which are characteristic of the sample, stages that have not yet indicated greater deterioration of the balance reactions. But the question arises, when considering stages above 3 on the HY scale, which indicate postural instability with a retropulsion test, considering that the absence of the effect of the disease's evolution on anteroposterior body oscillations with visual restriction is preserved, and also considering a strong mechanical disturbance that produces balancing reactions, the absence of the effect from the disease's progress in the anteroposterior body oscillations with visual restriction is preserved in the initial stages as much as in the moderate HY.

The anteroposterior oscillations of the head with dynamic and static tests in the two vision conditions with elderly people with PD were evaluated on the elderly who had fallen, as well as on those who had not. Those who had fallen showed an increase in head oscillations, which increased with the effect of Levodopa, indicating a tendency of the medication to worsen the balancing capacity.[24] In the present study, 6 people with PD used Levodopa, a condition that raised the idea of a possible interference of the medication on the body oscillation angles, but in this case, such interference is unknown. Still, there is another question about whether, considering stages above 3 in the HY scale, the absence of effect of the disease's progress in the anteroposterior body oscillations with visual restriction is preserved, considering the history of falls.

The initial stages of the disease did not have any effect on body oscillations in the stationary erect posture of the elderly people with PD analyzed in this study. Taking into account that our understanding of the progress profile of PD is still poor,[34] and that on many occasions the oscillatory behavior of the body has been contradictory in this population,[35] it can be said that there is a lack of better evidence and understanding of the behavior of

Table 2. Average and standard deviation values of the anteroposterior body oscillation angles (degrees) of the 10 participants in the eyes-open (EO) and eyes-closed (EC) conditions

Participants	A	B	C	D	E	F	G	H	I	J
EO	0.32 ± 0.22	0.11 ± 0.08	0.14 ± 0.12	0.30 ± 0.16	0.17 ± 0.11	0.23 ± 0.15	0.24 ± 0.17	0.19 ± 0.14	0.12 ± 0.08	0.28 ± 0.16
EC	0.39 ± 0.28	0.11 ± 0.09	0.15 ± 0.12	0.34 ± 0.20	0.24 ± 0.14	0.22 ± 0.15	0.30 ± 0.24	0.24 ± 0.16	0.27 ± 0.14	0.23 ± 0.13

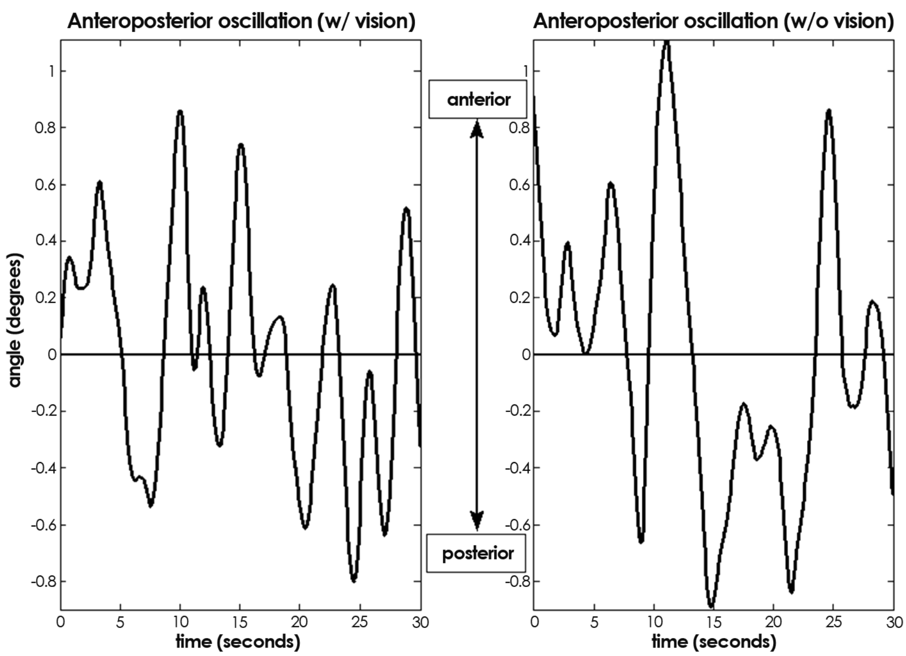

Figure 3. Representation of the anteroposterior body oscillation angles of one participant in the eyes-open and eyes-closed conditions

body oscillations, changes in static balance, and postural control as phenomena that accompany the disease in the course of time.

CONCLUSION

Finally, the results allowed us to conclude that there was a visual restriction effect on the anteroposterior body oscillation angles in the almost static erect posture, which were increased under the eyes-closed condition; the anteroposterior oscillation angles did not differ among themselves when stages 1 and 2 of the HY scale were considered, and regardless of the initial clinical progress stages of the disease, the vision conditions interfered with the almost static erect posture of the elderly with PD.

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