

Comparative Analysis of Postural Balance in Elderly Individuals With and Without Parkinson's Disease

Análise Comparativa do Equilíbrio Postural em Indivíduos Idosos com e sem Doença de Parkinson

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Abstract

Parkinson's disease is an age-dependent neurodegenerative disease, the prevalence of which increases among older individuals. The aim of the present study was to perform a comparative analysis of postural balance among elderly individuals with Parkinson's (Parkinson Group – PG) and elderly individuals without Parkinson's (Non-Parkinson Group – NPG) as well as a control group (CG) of younger adults, using balance platform parameters. The study was carried out at a medical and geriatric clinic in the city of Jales, SP, Brazil. Twenty-six elderly individuals with Parkinson's and 25 without Parkinson's were selected. The CG was made up of 20 young adults. Mean age in the groups was 75.09 ± 6.61 , 73.86 ± 8.12 , and 35.90 ± 7.88 , respectively. A balance platform (Footwork) was used for the data acquisition. There were no statistically significant differences between the PG and NPG regarding displacement velocity (P) or radial displacement (Rd) for the right and left feet ($p > 0.05$), whereas there was a significant increase in these parameters in both elderly groups when compared to the CG ($p < 0.001$). Regarding Parkinson Stages I, II and III, there was a tendency toward an increase in P and Rd values in Stage III. The data of the present study demonstrated no statistically significant differences between elderly individuals with and without Parkinson's disease regarding the variables P and Rd , while there was a significant increase in the value of these parameters when comparing elderly individuals to younger adults.

Keywords: Parkinson Disease. Aged. Postural Balance.

Resumo

A doença de Parkinson é uma doença idade-dependente neurodegenerativas, cuja prevalência aumenta entre os indivíduos mais velhos. O objetivo do presente estudo foi realizar uma análise comparativa do equilíbrio postural em indivíduos idosos com Parkinson (Parkinson Grupo - PG) e idosos sem (Non-Parkinson Group - NPG) de Parkinson, bem como um grupo controle (GC) de jovens adultos, utilizando parâmetros de plataforma de equilíbrio. O estudo foi realizado em uma clínica médica e geriatria na cidade de Jales, SP, Brasil. Vinte e seis indivíduos idosos com Parkinson e 25 sem Parkinson foram selecionados. O GC foi formado por 20 adultos jovens. A média de idade dos grupos foi $75,09 \pm 6,61$, $73,86 \pm 8,12$ e $35,90 \pm 7,88$, respectivamente. Uma plataforma de equilíbrio (Footwork) foi utilizada para a aquisição de dados. Não houve diferenças estatisticamente significativas entre os PG e NPG sobre velocidade de deslocamento (P) ou o deslocamento radial (Rd) para os pés direito e esquerdo ($p > 0,05$), enquanto houve aumento significativo nesses parâmetros em ambos os grupos de idosos quando comparado ao GC ($p < 0,001$). Sobre Estágios Parkinson I, II e III, houve tendência de aumento nos valores de P e Rd no Estágio III. Os dados do presente estudo não demonstraram diferenças estatisticamente significativas entre os indivíduos idosos com e sem doença de Parkinson em relação às variáveis P e Rd , enquanto houve aumento significativo no valor destes parâmetros quando comparamos os indivíduos idosos com adultos mais jovens.

Palavras-chave: Doença de Parkinson. Idoso. Equilíbrio Postural.

1 Introduction

Parkinson's disease is an essentially neurodegenerative disease with a progressive evolution, characterized by the loss of dopaminergic neurons located in the compact part of the *substantia nigra*, leading to motor disorders¹. This disease has five distinct, progressive stages, which begin with the patient demonstrating mild symptoms and end with extreme functional disability. Parkinson's is characterized by muscle rigidity, shuffling gait, curved posture and rhythmic muscle tremors².

Like most neurodegenerative diseases, Parkinson's is age dependent. Hence, its prevalence increases among older individuals. It is estimated that there is a 1% increase

in this pathology in individuals over 65 years of age³. The World Health Organization considers elderly individuals in developing countries to be those aged 60 years or more, whereas elderly individuals in developed countries are considered to be those aged 65 years or more. In 1950, there were approximately 204 million elderly individuals throughout the world. This number nearly tripled by 1998 and it is predicted that there will be 1.9 billion individuals over 60 years of age by 2050⁴.

Elderly individuals exhibit a physiological reduction in muscle strength, joint movement and adaptive reflex capacity. With age, these individuals experience changes in postural control mechanisms. This has a harmful effect on the

visual, vestibular and proprioceptive systems, which assist in balance⁵. Elderly individuals are often subject to falls, which are determined by both intrinsic and extrinsic factors⁶.

Postural control is a complex process that depends on the integration of vision, vestibular and peripheral sensations, commands of the central nervous system and neuromuscular responses, especially muscle strength and reaction time⁷. Postural stability is defined as the ability to maintain and control the center of mass of the body within the support base in order to prevent falls and control desired movements⁸.

Postural instability in Parkinson's occurs due to the loss of postural adaptation reflexes manifested during abrupt changes in gait, which leads to frequent falls⁹. Changes in balance occur in advanced stages of the disease and are more evident during changes in position, such as standing up from a chair or turning around^{10,11}. Such changes have considerable clinical importance due to the correlation with hip fractures and difficulty in the dissociation of the waist, scapulae and pelvis during gait^{10,12}.

A balance platform is a device for measuring static posturography and is commonly used in the qualification of balance in the standing position. A balance platform allows the evaluation of postural oscillations and variations in displacement velocity from the center of pressure of the feet, providing values that ensure statistically valid comparisons¹³.

The aim of the present study was to perform a comparative analysis of static balance among elderly individuals with and without Parkinson's with no visual restrictions.

2 Material and Methods

A controlled, cross-sectional study was carried out at a private medical and geriatric clinic in the city of Jales, SP, Brazil. All participants signed terms of informed consent and the study received approval from the Ethics Committee of the *Universidade do Vale do Paraíba* in compliance with Resolution 196/96 of the Brazilian National Health Council.

The sample was made up of 26 elderly individuals with Parkinson's (Parkinson Group – PG), 25 elderly individuals without Parkinson's (Non-Parkinson Group – NPG) and 20 younger adults (Control Group – CG). Mean age in the groups was 75.09 ± 6.61 , 73.86 ± 8.12 and 35.90 ± 7.88 , respectively. The PG included patients with Stage I, II and III Parkinson's based on the Hoehn and Yahr scale¹², with no difficulties in maintaining an orthostatic position and no severe cognitive impairment. Individuals with a history of stroke, lasting effects from poliomyelitis or other neurological diseases were excluded from the study.

A balance platform from the *Footwork* analysis system with 2704 sensors (7.62 x 7.62 mm) was employed. This platform allows an analysis of balance, pressure load on the feet in both static and dynamic erect positions and a baropodometric analysis for the measurement and comparison of pressure in different points of the plantar region in the

orthostatic position. This equipment includes a 16-bit A/D converter and the sampling frequency is 250 Hz.

An initial evaluation was carried out, which consisted of information on personal data, medical history, duration of the disease, stage of the disease, family history, co-morbidities, visual impairment, vestibular impairment, laboratory exams, current medications, weight, height, shoe size and dominant side. Balance assessment was performed using a balance platform. The individuals were placed in an unrestricted standing position with no support, barefoot, arms alongside the body and eyes focused on a visual target located at a distance of approximately one meter, positioned at the height of the glabella of each individual. Signal acquisition time was 20 seconds and all participants remained with their eyes open.

Data on postural oscillation from the center of mass of the body in the anteroposterior (x) and mediolateral (y) directions and for the right and left feet were analyzed using the Origin software program version 6.0 (Microcal), following the method described by Ribeiro¹⁴. The following variables were calculated:

Velocity of center of pressure displacement (P) – the mean distance traveled per second during the sampling period, calculated as follows:

$$P = \frac{f}{(N-1)} \sum_{i=1}^{N-1} \sqrt{\{(x_{i+1} - x_i)^2 + (z_{i+1} - z_i)^2\}}$$

in which f is the frequency of the sample (N/T), with N = the number of points recorded and T = data collection time; x_i and z_i are the coordinates of the center of pressure at each instant in the mediolateral and anteroposterior directions, respectively, in the sample index i ;

Radial displacement from the center of pressure (Rd) – the oscillation of the center of pressure, based on the following formula:

$$Rd = \frac{1}{N} \sum_{i=1}^N \sqrt{\{(x_i - x_c)^2 + (z_i - z_c)^2\}}$$

$$x_c = \frac{1}{N} \sum_{i=1}^N (x_i) \quad z_c = \frac{1}{N} \sum_{i=1}^N (z_i)$$

in which x_c and z_c are the coordinates of the center point and x_i and z_i are the displacements around this point.

The entire sequence of data analysis and calculation of the equations was performed using the Origin 6.0 (Microcal) program. Comparisons of P and Rd were made between groups (PG, NPG and CG) as well as between right and left sides. Descriptive analysis of P and Rd was also performed

for the individuals in the Parkinson Group based on the stage of the disease (I, II or III). The Newinstat 2.0 and Microcal Origin 6.0 software programs were used for the calculations and construction of graphs.

For statistical analysis, normality (Kolmogorov-Smirnov) and homogeneity of variance (Levene's) tests were first applied. The data were then analyzed using Barlett's method to determine whether the standard deviations were similar, in which case one-way analysis of variance (ANOVA) and the Tukey-Kramer test were used for multiple comparisons of parametric data. Otherwise, the data were considered non-parametric and the Kruskal-Wallis ANOVA and Dunn's test for multiple comparisons were used. The level of significance was set at 5%.

3 Results and Discussion

Table 1 displays the anthropometric data on the individuals of the present study.

Table 1: Anthropometric data

	Individuals (n)	Age (years)	Weight (Kg)	Height (m)	Gender F/M
Elderly with Parkinson's	26	75.09 ± 6.61	68.26 ± 17.44	1.59 ± 0.07	8/18
Elderly without Parkinson's	25	73.86 ± 8.12	64.74 ± 13.15	1.60 ± 0.09	12/13
Control	20	35.90 ± 7.88	67.35 ± 22.13	1.68 ± 0.09	10/10

The statistical analysis revealed no significant differences ($p > 0.05$) between the elderly individuals with and without Parkinson's (PG and NPG) regarding the value of P for the body, right foot or left foot, whereas both groups obtained significantly higher mean values in comparison to the CG ($p < 0.001$). There were no significant differences regarding the value of Rd for the body between the PG and NPG ($p > 0.05$), whereas the CG obtained significantly lower values than both elderly groups ($p < 0.001$) (Figure 1).

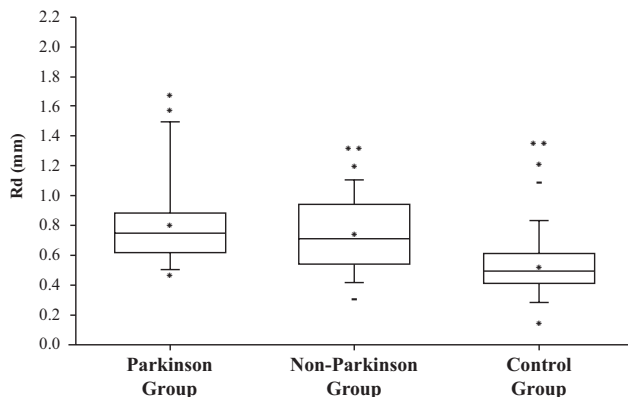


Figure 1: Mean body Rd values of Parkinson, Non-Parkinson and Control groups

There were no significant differences regarding the value of Rd for the right foot between the PG and NPG ($p > 0.05$), whereas the CG obtained significantly lower values than both elderly groups ($p < 0.001$) (Figure 2).

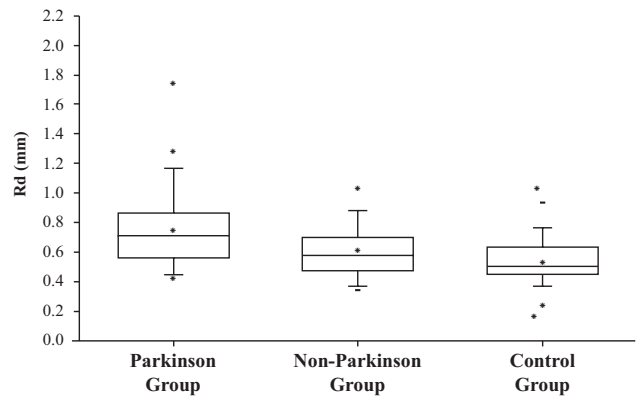


Figure 2: Mean right Rd values of Parkinson, Non-Parkinson and Control groups

There were no significant differences regarding the value of Rd for the left foot between the PG and NPG ($p > 0.05$), whereas the CG obtained significantly lower values than both elderly groups ($p < 0.001$) (Figure 3).

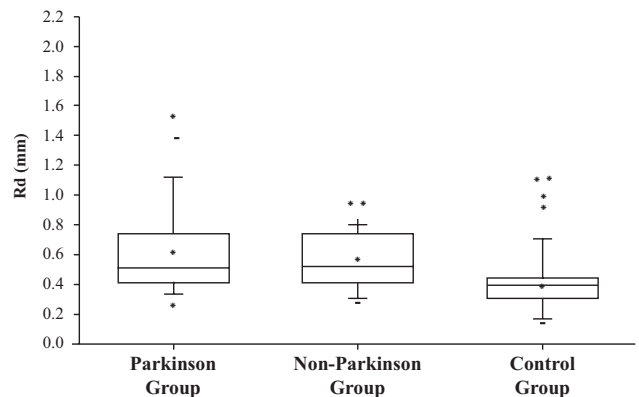


Figure 3: Mean left Rd values of Parkinson, Non-Parkinson and Control groups

The analyses of the right and left sides in the three groups revealed no statistically significant differences regarding mean P and Rd values. In the PG, the analysis of mean P and Rd values in Stages I, II and III was only carried out descriptively due to the small number of individuals in Stage III. There was a tendency toward an increase in mean values for P in Stage III for the body, right foot and left foot (Figure 4). Mean Rd increased between Stages I and II, with a drop in values in Stage III.

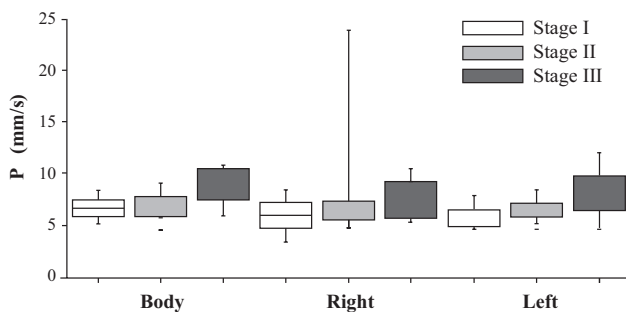


Figure 4: Mean values of body, right and left P of Stages I, II and III in the Parkinson group

Elderly individuals are more prone to falls due to intrinsic aspects stemming from senescence and extrinsic aspects caused by the aging process. Falls are more frequent among patients with Parkinson's disease. The main risk factors listed in the literature are advanced age, long duration of disease, previous history of falls, changes in gait, loss of waist dissociation and reduction in postural reflexes (straightening, balance and protective extension reactions). Most studies on balance in individuals with Parkinson's report alterations in the visual, vestibular and proprioceptive systems, which cause postural oscillations and consequent falls^{6,15-17}.

The present study demonstrated that elderly individuals with and without Parkinson's had a statistically significant increase in P and Rd values for the body, right foot and left foot in comparison to the group composed of younger adults (CG) during the balance platform analysis in an orthostatic position with eyes open. These results are similar to those described by Termoz *et al.*¹⁸, who found greater ranges in P and Rd values when comparing elderly individuals and young adults as well as a similar oscillation amplitude when comparing elderly individuals with and without Parkinson's.

There were no statistically significant differences in P and Rd values for the right and left feet between the individuals in the PG and NPG. Conflicting with this result, Blaszczyk *et al.*¹⁹ found statistically significant differences between elderly individuals with and without Parkinson's in an analysis of oscillation during a static posturographic exam. However, the authors carried out the exam with no visual system, as the participants remained with eyes closed, whereas the participants in the present study performed the test with eyes open.

Studies have shown greater oscillation in balance when the visual system is not employed. In a study on elderly individuals with and without Parkinson's assessing postural oscillation on a balance platform, Brown *et al.*²⁰ instructed the participants to remain with their eyes open for 15 seconds, then closed for 15 seconds and open again for 15 seconds. The authors found that balance was affected in both groups when the visual system was not involved. However, there was a greater difference in the group with Parkinson's. This may have occurred due to the difficulty such individuals have in

sensory-motor reorganization. De Nunzio *et al.*²¹ found that patients with Parkinson's are less capable of adapting to sensory modalities, which is reflected in a change in postural strategies with the eyes open when compared to eyes closed. This may contribute to the high incidence of falls among patients with Parkinson's.

Previous studies have shown that there are no significant differences in postural control strategy between elderly individuals with and without Parkinson's^{18,22}. This was corroborated by the results of the present study, which demonstrated that these populations exhibit a very similar number and range of alterations, indicating that the presence of Parkinson's has no influence over the task performed. These results may be explained by the aging process in both groups of elderly individuals, as adequate functioning of the postural system involves the control of body segments based on sensory information²³.

A large number of studies report that postural instability in patients with Parkinson's occurs due to disturbances in the motor programming during postural corrections (efferent deficiency). However, Vaugoyeau *et al.*²⁴ assessed deficiency in vertical postural control and impairment in proprioceptive integration in patients with Parkinson's using a balance platform and found a decline in the variables studied, but corrections could be made using visual feedback. This indicates that postural instability occurs not only due to efferent deficiency, but afferent deficiency as well.

There were no statistically significant differences in any of the groups (PG, NPG and CG) between the right and left feet regarding mean P and Rd values. There was an increase in mean P of the right and left feet in Stage III of the disease in the assessment of this parameter in the PG. Mean Rd underwent an increase between Stages I and II, with a later drop in value in Stage III. This result may be explained by the fact that postural instability clinically manifests itself beginning with Stage III, according to Gagey and Weber²⁵. It is likely that, in Stages I and II, individuals with Parkinson's have the same somato-sensory and musculoskeletal alterations as healthy elderly individuals. Moreover, Parkinson's is primarily a motor disease and alterations may initially lead to postural changes due to the deficit in the musculoskeletal system and subsequent balance deficiency.

It should be stressed that the results of the present study cannot be generalized for the population of elderly individuals with Parkinson's due to the small sample size. Further studies with a larger number of participants based on an adequate sample calculation are needed to corroborate the results. However, this study is important to clinical practice, as it highlights the aggravation of postural instability with the progression of the disease and the need to identify the influence of each stage of Parkinson's over balance. Thus, preventive measures aimed at preventing possible falls can be adopted.

4 Conclusion

Based on the results of the present study, Parkinson's disease did not lead to greater impairment with regard to static balance in the population of elderly individuals studied. Regardless of the absence or presence of this degenerative disease, age older than 60 years resulted in greater instability in the orthostatic position in comparison to younger adults. The stages of Parkinson's were directly proportional to the worsening in static balance. Hypothetically, manifestations of postural instability begin to appear with greater accentuation in Stage III of the disease.

References

1. Sptiz M, Barbosa ER. Parkinson's in patients with gaucher's disease. *Rev Bras Neurol* 2005;41(1):5-9.
2. Antoniadis CA, Barker RA. *The search for biomarkers in Parkinson's disease: a critical review. Neurotherapeutics* 2008;8(12):1841-52.
3. Cordeiro RC, Franco VC, Couto FBD, Palinkas E, Mello MAF, Perracini MR *et al.* Proposta de abordagem multidisciplinar em pacientes idosos portadores de doença de Parkinson. *Gerontologia* 1999;7(2):7-14.
4. IBGE – Instituto Brasileiro de Geografia e Estatística. Perfil dos idosos responsáveis pelos domicílios no Brasil. Rio de Janeiro: IBGE; 2002.
5. Wiecek SA. Equilíbrio em adultos e idosos. Relação entre tempo de movimento e acurácia durante movimentos voluntários na postura em pé. São Paulo. Dissertação [Mestrado em Educação Física] - Escola de Educação Física e Esporte. Universidade de São Paulo; 2003.
6. Pickering RM, Grimbergen YAM, Rigney U, Ashbum A, Mazibrada G, Wood B *et al.* A meta-analysis of six prospective studies of falling in Parkinson's disease. *Mov Disord* 2007;22:1892-900.
7. Overstall P. The use of balance training in elderly people with falls. *Rev Clin Gerontol* 2003;13(02):153-61.
8. Swanenburg J, De Bruin ED, Favero K, Uebelhart D, Mulder T. The reliability of postural balance measures in single and dual tasking in elderly fallers and non-fallers. *BMC Musculoskelet Disord (Online)* 2008;9(1):162.
9. Cunnington R, Lalouschek W, Dirnberger G, Walla P, Lindinger G, Asenbaum S *et al.* A medial to lateral shift in pre-movement cortical activity in hemi - Parkinson's disease. *Clin Neurophysiol* 2001;112:608-18.
10. Ferraz HB, Borges, V. Doença de Parkinson. *RBM Rev Bras Med* 2002;59(4):207-19.
11. Limongl, JCP. Alternativas terapêuticas nas complicações motoras decorrentes do tratamento crônico da doença de Parkinson: SNC em diabetes. *Novartis* 2003;2(1):15-1.
12. Stack EL, Ashbum AM, Jupp KE. Strategies used by people with Parkinson's disease who report difficulty turning. *Parkinsonism Relat Disord* 2006;15:87-92.
13. Oliveira LF, Simpsom DM, Nadal J. Calculation of area of stabilimetric signals using principal component analysis physiological measurement. *Bristol* 1996;17:305-11.
14. Ribeiro DCL. Estudo do controle postural na posição ortostática de pacientes hemiparéticos por meio da análise de parâmetros estabilométricos. São José dos Campos. Dissertação [Mestrado em Engenharia Biomédica] - Universidade Vale do Paraiba; 2005.
15. Hoehn MM, Yahr MD. Parkinsonism: onset, progression and mortality. *Neurology* 1967;17:427-42.
16. Chu LW, Chi I, Chiu AY. Incidence and predictors of falls in the Chinese elderly. *Ann Acad Med Singapore* 2005;34(1):60-72.
17. Wielinski CL, Erickson-Davis C, Wichmann R, Walde-Douglas M, Parashos AS. Falls and injuries resulting from falls among patients with Parkinson's disease and other parkinsonian syndromes. *Mov Disord* 2004;20(4):410-5.
18. Termoz N, Halliday SE, Winter DA, Frank JS, Patla AE, Prince F. The control of upright stance in young, elderly and persons with Parkinson's disease. *Gait Posture* 2008;27:463-70.
19. Blaszczyk JK, Orawiec R, Duda-Klodowska D, Opala G. Assessment of postural instability in patients with Parkinson's disease. *Ex Brain Res* 2007;183:107-14.
20. Brown LA, Cooper SA, Doan JB, Dickin DC, Whishaw IQ, Pellis SM, *et al.* Parkinsonian deficits in sensory integration for postural control: Temporal response to changes in visual input. *Parkinonism Relat Disord* 2006;12:376-81.
21. De Nunzio AM, Nardone A, Schieppati M. The control of equilibrium in Parkinson's disease patients: Delayed adaptation of balancing strategy to shifts in sensory set during a dynamic task. *Brain Res Bull* 2007;74:258-70.
22. Duarte, M. Análise estabilográfica da postura ereta humana quase-estática. São Paulo. Tese [Livre Docência em Biomecânica] - Escola de Educação Física e Esporte. Universidade de São Paulo; 2000.
23. Ruwer SL, Rossi AG, Simon LF. Equilíbrio no idoso. *Rev Bras Otorrinolaringol* 2005;71(3):298-303.
24. Vaugoyeau M, Viel S, Assaiante C, Amblard B, Azulay JP. Impaired vertical postural control and proprioceptive integration deficits in Parkinson's disease. *Neuroscience* 2007;146: 852-63.
25. Gagey PM, Weber B. Posturologia. Regulação e distúrbios da posição ortostática. São Paulo: Manole; 2000.

