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ORIGINAL RESEARCH

Impact of Parkinson's disease in the performance of balance with different attentional demands

Impacto da doença de Parkinson na performance do equilíbrio em diferentes demandas atencionais

Impacto de la enfermedad de Parkinson en el equilibrio en distintas situaciones propuestas

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ABSTRACT | This study aimed to evaluate the balance of Parkinson's disease (PD) patients in Tandem stance with eyes open (EO), eyes closed (EC), and in dual task condition (DT). This is a cross-sectional study, composed of 19 individuals with mild to moderate PD. Patients were evaluated in a BIOMEC400 force platform. The parameters analyzed were: area of the foot center of pressure (COP), COP amplitude and speed, in the anteroposterior (AP) and mediolateral (ML) directions. We found statistically significant results for AP and ML amplitude of the COP and COP area, with higher values for the stances EC Tandem and DT Tandem, when compared with EO Tandem. The values of AP and ML average speed were higher in EC Tandem when compared with EO Tandem (P=0.009 and P=0.000), respectively. We concluded that, when individuals with PD undergo cognitive challenges, they behave as if they were with eyes closed regarding balance changes. This reinforces the need to introduce, in the therapeutic plan of these individuals, activities that require the practice of these skills.

Keywords | Postural Balance; Parkinson's Disease; Physical Therapy Modalities.

RESUMO | O objetivo deste estudo foi avaliar o equilíbrio de pacientes com doença de Parkinson (DP) na posição de tandem com os olhos abertos (OA), olhos fechados (OF) e em condição de dupla tarefa (DT). Trata-se de um estudo transversal composto por 19 indivíduos com DP nos estágios leve a moderado. Os pacientes foram avaliados em uma plataforma de força Biomec400. Os parâmetros analisados foram a área do centro de pressão dos pés (COP) e a amplitude e velocidade do COP nas direções anteroposterior (AP) e mediolateral (ML). Foram encontrados resultados estatisticamente significantes para amplitude AP e ML do COP e da área do COP, com valores maiores para as posições em tandem de OF e tandem com DT, quando comparados com a posição em tandem de OA. Os valores de velocidade média AP e ML foram maiores na posição em tandem de OF em comparação ao tandem de OA (p=0,009 e p=0), respectivamente. Concluiu-se que indivíduos com DP, quando submetidos a desafios cognitivos, comportam-se de forma semelhante à retirada do recurso visual no que diz respeito às alterações de equilíbrio. Isso reforça a necessidade de introduzir no plano terapêutico desses indivíduos atividades que requeiram o treino dessas habilidades.

Descritores | Equilíbrio Postural; Doença de Parkinson; Modalidades de Fisioterapia.

RESUMEN | El propósito de este estudio fue evaluar el equilibrio de pacientes con enfermedad de Parkinson (DP) en la posición tándem con los ojos abiertos (OA), ojos cerrados (OC) y en condición de doble tarea (DT). Se trata de un estudio transversal, del cual participaron 19 personas con DP en etapas leve a moderada. Se evaluaron

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a los pacientes en una plataforma de fuerza Biomec400. Los parámetros evaluados fueron el área del centro de presión de los pies (COP) y la amplitud y velocidad del COP en las direcciones anteroposterior (AP) y mediolateral (ML). Se encontraron resultados estadísticamente significativos para la amplitud AP y ML del COP y del área del COP, con mayores valores para las posiciones tándem con OC y tándem en DT, en comparación a la posición tándem con OA. Los valores de la velocidad media AP y ML fueron mayores en la posición tándem de OC comparados a la tándem de OA (p=0,009 y p=0, respectivamente). Se concluye que los sujetos con DP, en el momento que se les sometieron a los desafíos cognitivos, se portaron de manera semejante cuando se les taparon los ojos en lo que se refiere a las alteraciones de equilibrio. Este resultado señala la necesidad de introducir en la fisioterapia de los pacientes con DP actividades que les exigen el entrenamiento de estas habilidades.

Palabras clave | Balance Postural; Enfermedad de Parkinson; Modalidades de Fisioterapia.

INTRODUCTION

Balance disorders in individuals with Parkinson's disease (PD) can occur at different stages of the disease, increasing their physical disability[1]. This can be justified by the impairment of the central nervous system's ability to process vestibular, visual, and proprioceptive afferences, which normally interprets them to generate the appropriate muscle responses that are responsible for the maintenance of body balance[2,3].

In addition, individuals with PD have difficulty in automatizing movements, which increases their attentional demand during daily activities and generates difficulties in associating a cognitive task with a motor task (dual task) simultaneously, which depends on cognitive processes involving executive function, attention, and memory[4-6]. Thus, it is important that dual tasks (DT) are included in the evaluations and therapeutic procedures of these patients, since these are a prerequisite for the performance of various tasks of their daily life[7].

To obtain a good postural control, it is necessary to maintain the center of mass within the limits of stability in static or dynamic condition, as well as to control the position of the body in space[8]. For this, there is the interaction of multiple systems, which comprise biomechanical components, sensory strategies, anticipatory and reactive mechanisms, stability limits, and perceptual and cognitive system[9,10].

For its evaluation, the gold standard instrument is posturography, which is based on the determination of variables associated with the displacement of the foot center of pressure (COP), which is the point of application of the resulting vertical forces acting on the support base. The variables measured by the platform identify small changes in stance, which are highly sensitive to determine the quality of the postural control[11].

We chose to assess balance in Tandem stance because of its functional importance, especially in gait, where this stance is essential. The difficulty in performing gait in Tandem may be related to the increased postural instability in mediolateral direction, which can result in falls, in addition to contribute to the global severity of the disease[12].

In view of the functional importance of this topic, this study aimed to evaluate balance in Tandem stance with eyes open (EO), eyes closed (EC), and dual task (DT) in this population.

METHODOLOGY

This was a cross-sectional study, in which we included individuals of both sexes, aged above 50 years, and with diagnosis of idiopathic PD according to the criteria of the London Brain Bank[13], from the neurology outpatient clinic of the Clinical Hospital of Londrina State University – in partnership with the Laboratory of Functional Evaluation and Human Motor Performance of Norte do Paraná University, in Londrina, Paraná –, in mild to moderate stage according to the modified Hoehn & Yahr scale (HY)[14], able to walk by themselves, and not enrolled in other therapeutic programs besides the drug treatment. We excluded from the study patients with other neurological, musculoskeletal, and associated disorders and cognitive changes that could interfere in the evaluation process.

After being informed about the purposes of the study and evaluation procedures, all involved agreed to participate in the study and signed the informed consent form. The study was approved by the Human

Subject Research Ethics Committee of Londrina State University under Opinion no. 028/2013, in accordance with the guidelines of resolution 466/2012 of the National Health Council. All evaluation procedures were performed in the medication period, with the following instruments:

Modified Hoehn & Yahr scale (HY): evaluates the staging of the disease and the disability of individuals with PD. Its modified form comprises seven stages of classification regarding the severity of the disease, and, for this study, we selected patients classified between stages 1.5 and 3 (mild to moderate disability)[14].

Unified Parkinson's Disease Rating Scale (UPDRS): evaluates the progression of the disease according to its clinical characteristics, composed of 42 items, divided into four domains. The score on each item varies from 0 to 4, and, the higher the score, the greater the impairment of the disease. We used the domains of activities of daily life (part II) and motor examination (part III)[15].

Mini-Mental State Examination (MMSE): evaluates the cognitive functions, composed of questions grouped into seven categories, each aiming to evaluate cognitive functions, such as orientation in time and space, record and memory of words, language, attention and calculation, and visual constructive capacity. The score can vary from 0 to 30 points, in which the cut off of 24 has from good to excellent sensitivity and specificity for the diagnosis of dementia[16].

BIOMEC400 force platform (EMG System do Brasil, São Paulo, Brazil). For balance evaluation, the protocol took place as follows: 1) Tandem with eyes open (EO); 2) Tandem with eyes closed (EC); 3) Tandem with dual task with eyes open, performing simple mathematical operations simultaneously with balance measures (DT). The tasks were performed twice for 30 seconds each, with rest intervals between them, and we obtained the average values of both attempts for the analyses. During the tasks with EO, participants should look for a black stripe put on the wall ahead, two meters away. For patient safety, a trained evaluator remained at their side during evaluation, without interfering in data collection. Patients chose the foot placed behind to perform the examination[17].

The signs of vertical ground reaction force are derived from a sample of 100 Hz for data collection and filtered with a low passband 35 Hz second-order filter (Butterworth filter) to eliminate electrical noises. Then, we conducted stabilographic analyses with the Bioanalysis software of BIOMEC400 platform, compiled with MATLAB analyses computation routines (The Mathworks, Natick, MA), to extract the main parameters of COP oscillation: area (cm^2), amplitude (cm^2), and speed (cm/s), in the anteroposterior (AP) and mediolateral (ML) directions[18].

Statistical analysis

Data were analyzed according to normal distribution and represented by mean and standard deviation, using ANOVA. We used Tukey's post-test to obtain values of minimum significant difference. The significance value was 5% ($p<0.05$) and the analysis was conducted by the SPSS 20 program.

RESULTS

Table 1 shows the initial characteristics of the groups. Values were expressed as mean and standard deviation. We included 19 individuals in the study (12H), with average age of 71 years (SD=7.8).

Table 1. Sample characterization

Variable	Values
Age (years)	71 [7.8]
Weight (kg)	74.1 [17.4]
Height (meters)	1.65 [0.08]
BMI (kg/m^2)	26.8 [5.4]
H&Y	2.6 [0.49]
UPDRS (ADL)	9 [4]
UPDRS (motor)	19.8 [9.4]
UPDRS (total)	28.8 [12.2]
MMSE	26.9 [3.1]
Time since diagnosis (years)	5.2 [3.4]

Kg: kilograms; m^2: square meters; BMI: body mass index; H&Y: Hoehn and Yahr stage scale; UPDRS: Unified Parkinson's Disease Rating Scale; MMSE: mini-mental state examination

Table 2 shows the values referring to the evaluation on the platform. In the variable AP amplitude, we found statistically significant difference between the values of EO and DT Tandem, with values that indicate greater postural instability for the stance with DT. For ML amplitude and area, we found statistically significant difference between EC Tandem *versus* EO Tandem and DT Tandem *versus* EO Tandem, and the results of EC and DT Tandem indicate greater balance deficit. Regarding the variables AP and ML speed, we verified difference between the stances EO Tandem and EC Tandem. We found no difference between the values of EC and DT Tandem in any of the variables here analyzed.

Table 2. Results of the evaluation of Tandem stance, with EO, EC, and DT

	EO Tandem	EC Tandem	Dual Task	P
AP Amplitude	2.59 (0.92)	3.54 (SD 1.10)	4.68 (SD 2.57)*	0.002
ML Amplitude	4.04 (SD 0.84)	5.29 (SD 1.24)*	4.90 (SD 0.95)*	0.002
Area	6.25 (SD 3.11)	10.64 (SD 6)*	10.22 (SD 6.08)*	0.023
AP average speed	1.80 (SD 0.49)	2.96 (SD 1.53)*	2.44 (SD 1.08)	0.009
ML average speed	2.06 (SD 0.50)	3.28 (SD 0.97)*	2.33 (SD 0.64)	0.000

Note: * difference versus EO Tandem
EO: eyes open; EC: eyes closed; DT: dual task; AP: anteroposterior; ML: mediolateral; SD: standard deviation

DISCUSSION

The main results of this study showed a significant increase in the area of COP displacement in Tandem stance performed with EC and DT when compared with Tandem stance with EO. This probably is due to the increase in postural instability when the visual resource is removed or when there is association of a DT for maintaining balance on a narrow base. On the other hand, we found no difference in the area of COP displacement between the stances EC Tandem and DT Tandem, suggesting that patients have similar difficulty in the tests with EC and DT, i.e., keeping their postural control stable while performing DT is as difficult as keeping it with EC.

These findings reveal the difficulty of PD patients in maintaining stability when carrying out activities with DT, which may limit their functionality, since many everyday activities require the execution of different tasks simultaneously. Most studies found in the literature evaluate balance with patients in orthostatism and with feet positioned in parallel[19-23]. Previous studies suggest that simpler stances, such as two-feet position, present low difficulty demand for maintaining balance[24]. Thus, we chose to investigate Tandem stance associated with different attentional demands due to the scarcity of PD-related data in the literature and the importance of early diagnosis, because we believe that the balance evaluation in two-feet position may underestimate the patients' deficits and, therefore, the early intervention in balance disorders in these patients.

Regarding the choice of evaluating balance in association with DT, it is known that the environment forces individuals to split their attention between several stimuli that occur simultaneously, requiring fast and accurate motor responses. However, the ability to perform such tasks simultaneously is limited in patients with PD[25]. The gait, for example, by having a rhythmic and automatic behavior, is generated mainly by subcortical systems, which makes it be carried out without great attentional demand. Thus, the gait is impaired when conducted in DT condition by PD patients, due to an interference caused by the competition of attentional resources[26].

Floriano et al., in 2015, compared the performance of DT between older adults with PD and healthy older adults. The groups were subjected to five motor tasks and, subsequently, a cognitive task was associated with each of them. They verified worse performance in the time for carrying out DT for the PD group in comparison to the group of healthy older adults, signaling the negative interference of PD in performing DT and the importance of introducing activities that involve DT in the rehabilitation of PD[7].

In this sense, for verifying the impact of DT on stability and postural control, studies have compared the balance between healthy subjects and with PD in simple conditions and DT condition with EO and EC, in two-feet support. The results observed from the force platform showed that individuals with PD presented worse performance than healthy individuals in all evaluations, with higher values of COP displacement, corresponding to greater postural instability and, also, that the performance of the tests with EC and in association with DT are worse when compared to tests with EO for both groups[27-29]. These results confirm our findings, but we believe that the evaluation in Tandem position, for being more challenging, can be a more effective predictor of balance disorders, bringing additional information when compared to two-feet position, besides being a very important functional position to this population.

Finally, it is clear that patients with PD have difficulty maintaining their balance when subjected to challenging attentional demands, such as the removal of visual resource and addition of DT. For this reason, we emphasize the importance of inserting sensory components and practicing balance exercises with DT in PD treatment. We hope this study can contribute to the clinical practice in physical therapy and in future research involving physical therapy for individuals with PD.

Study limitations

As study limitations, it is important to note that we included individuals with PD only in stages 1.5 to 3 according to the modified HY scale, which hinder us to extrapolate our results to individuals classified in the severe stage of the disease, in addition to healthy people,

by their specificity for PD. Furthermore, the ideal time of permanence on the platform is 40 seconds, according to a study of Scoppa et al.; however, in our study, it may vary between 20 and 60 seconds, and we chose the duration of 30 seconds at each evaluated position[30].

CONCLUSION

We concluded that, when individuals with PD undergo cognitive challenges, they behave as if they were with eyes closed regarding balance changes. This reinforces the need for early introducing, in the therapeutic plan of these individuals, activities that require the practice of these skills.

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