Original Article

Dual task interference on gait performance in individuals with Parkinson Disease

Interferência da dupla tarefa no desempenho da marcha em indivíduos com doença de Parkinson

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ABSTRACT | BACKGROUND: Performing dual tasks simultaneously requires the ability to focus attention and perform two activities at the same time. In individuals with Parkinson's disease, the interferences may be greater, as these individuals require a major degree of attention just to perform a single task, as in this case, walking. **OBJECTIVE:** To analyze the interference of dual task in the gait of PD individuals. **MATERIAL AND METHODS:** Observational cross-sectional study with a prospective structure of a quantitative nature. Five individuals with Parkinson Disease, of both gender, participated in the experimental group; five healthy individuals were part of the control group. The participants had their gait assessed with and without cognitive interference, using: Berg's Balance Scale; Dynamic Gait Index; functional mobility test (Time Up and Go Test), Treadmill gait and Stroop Test adapted for illiterates. **RESULTS:** When comparing the Experimental Group and the Control Group, statistically significant differences were found in the gait conditions with dual task interference (Dual Task Number and Dual Task Color) in the variables of number of correct answers and range of motion. **CONCLUSION:** The dual task in PD patients mainly interferes with cognitive function, while the motor function of gait remains partially preserved.

KEYWORDS: Parkinson disease. Gait. Dual task.

RESUMO | INTRODUÇÃO: A realização de duas tarefas de forma simultânea exige a capacidade de concentrar atenção e executar duas tarefas ao mesmo tempo. Em indivíduos com Doença de Parkinson as interferências podem ser ainda maiores, visto que esses indivíduos necessitam de um grau maior de atenção apenas para executar uma tarefa única, como no caso, a marcha. **OBJETIVO:** Analisar a interferência da dupla tarefa na marcha de pacientes com DP. **MATERIAIS E MÉTODOS:** Estudo observacional de caráter transversal, de natureza quantitativa. Cinco indivíduos com Doença de Parkinson, de ambos os sexos, participaram do grupo experimental; e cinco indivíduos saudáveis fizeram parte do grupo controle. Os participantes tiveram a marcha avaliada com e sem interferência cognitiva, utilizando: Escala de Equilíbrio de Berg; Índice Dinâmico da Marcha; teste de mobilidade funcional (Time Up and Go Test), Esteira Ergométrica e o Stroop Test adaptado para analfabetos. **RESULTADOS:** Quando comparados Grupo Experimental e Grupo Controle foram encontradas diferenças estatisticamente significantes nas condições de marcha com interferência de dupla tarefa (Dupla Tarefa Número e Dupla Tarefa Cor) nas variáveis de quantidade de acertos e amplitude de movimento. **CONCLUSÃO:** A dupla tarefa em pacientes com DP, interfere principalmente na função cognitiva, enquanto a função motora da marcha permanece parcialmente preservada.

PALAVRAS-CHAVE: Doença de Parkinson. Marcha. Dupla tarefa.

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Background

Parkinson's Disease (PD) affects between 1 and 2% of people over 65 years old in the world, and with a prevalence of 3% in Brazil[1]. Gait disorders in PD are the main motor symptoms and one of the most disabling, causing reduced gait speed and smaller stride length to freezing of gait (FOG), which is characterized by sudden, relatively brief episodes of inability to produce effective forward stepping[2].

Gait is a dynamic process, controlled by the cortex, brain stem and spinal cord, where any deficiency in one of these systems can affect its control and regulation[3]. In particular, in the adaptations that these systems have to produce during the environmental restrictions present during gait, which can make it unsafe and incapacitating for individuals with PD[4].

There are many strategies used in gait rehabilitation in individuals with PD, one of which is the use of external visual cues[5]. Therapeutic approaches aim to improve gait parameters, including speed, cadence and stride length, among others.

Although walking is a predominantly automatic activity, in PD patients it requires a greater degree of attention[6]. The performance of two simultaneously tasks is influenced by the ability to effectively focus attention on simultaneous activities[7]. According to previous studies, this can be explained by the fact that individuals with PD present a sensorimotor impairment that decreasing automatic control, requiring greater attentional control during daily motor activities. Often, the effect of dual task is measured as an indicator of automation of motor control[8,9].

The dual task can cause damage to the gait performance, considering that in previous studies it was observed that under conditions of simultaneous tasks, the attentional demand is divided and the resources necessary to compensate the gait automation are not fully effective, imparing effective locomotion[10].

Thus, it is noted the importance of working on therapeutic activities that focus on the practice of the dual task, specifically in the use of practices that produce the cognitive and/or motor interference of one main activity instead of another. This practice must be carried out in a controlled environment to avoid falls and injuries, and can produce a dispute for the attention demand, so it is possible to transfer the skills learned to the patient's environmental conditions. However, some questions still need to be asked regarding the effects and the type of interference that must be offered during the practice of the dual task.

Some studies shows results that try to explain the doubts related to the theme using l tests, such as Stroop Test (ST) and Simbol Test, and demonstrate an increase in gait variability, when a cognitive task is proposed simultaneously[11]. Therefore, the aim of this study was to analyze the effects of dual task on gait in PD individuals.

Material and methods

This is an observational, cross-sectional and quantitative study, with a convenience sample, carried out from January 2018 to October 2019, at the Motricity and Human Physiology Laboratory and at the Physiotherapy Ambulatory at the Integrated Clinic at Faculty of Health Sciences at Trairi - Facisa / UFRN and approved by the Research Ethics Committee of the institution under the CAAE 2.715.132 (CAAE 89527318.3.0000.5568).

Participants

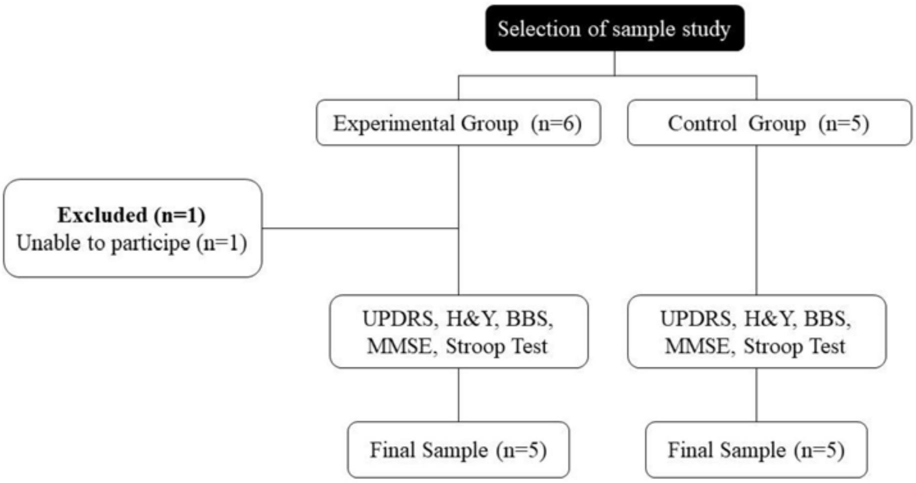
The study was divided into two stages: selection of patients with PD, and then evaluation of those who met the eligibility criteria. The selection of patients was based on data collected from the institution list of patients and through telephone contact, to obtain the informations about age, clinical and functional diagnosis, interesting and availability to participate of the study. Then, community controls individuals were recruited in order to match the group of PD patients.

Therefore, the study consisted of two groups: Experimental Group, which was composed of individuals with a clinical diagnosis of PD, all according to neurologist diagnosis, classified between stages 1 and 4 on the modified Hoenh & Yahr Sacale (H&Y), and who performed continuous use of PD medication; and Control Group, composed of individuals without any other neurological disease, recruited from the community.

For both groups, individuals were included if they scored higher than 24 (educated individuals) or higher than 14 (illiterate participants) in the Mini Mental State Examination (MMSE); and being over 40 years old. Both groups accepted to participate in the research and signed informed consent. Participants who presented joint deformities, arthritis or severe pain, or other neurological disorder concomitant with PD (specific to the EG) were excluded.

The study sample was initially composed of 11 individuals, of both gender, six from the Experimental Group and five from the Control Group. One eligible individual from Experimental Group were excluded, because were unable to participate of the study due to health issues, leaving five individuals in DP group. In the Control Group, the five individuals initially eligible, agreed to participate in all stages of the study (Figure 1).

Figure 1. Flowchart of study sample



Procedures

A trained therapist applied clinical instruments to characterize the sample and verify the eligibility criteria. The Mini Mental State Examination (MMSE) allows the assessment of cognitive function and dementia, and has a total score of 30 points.

The Unified Parkinson's Disease Rating Scale (UPDRS) examine the general effects of PD, consists in four domains that assess the progression of the disease according to its clinical characteristics and the effects of fluctuations related to the use of drugs, with a maximum score of 180 points. The score on each item ranges from 0 to 4, where higher scores means greater severity of the disease[12]. In this study, two UPDRS domains were used: activities of daily living and motor exam.

The modified Hoehn & Yahr Scale (H&Y) measures the state of severity of PD in eight stages. The score zero (0) means no sign of the disease and at stage five the patient is in a wheelchair, unable to perform daily activities without help[13].

The Berg Balance Scale (BBS) is an instrument that measures functional balance and consisting of 14 items. For each item the score varies between zero to four points, with the maximum score being 56 points. The score varies according to the level of dependence to perform the task. Scores between zero and twenty points correspond to wheelchair restriction; between 21 to 40 points refer to assistance during walking; and 41 to 56 points correspond to independence[14].

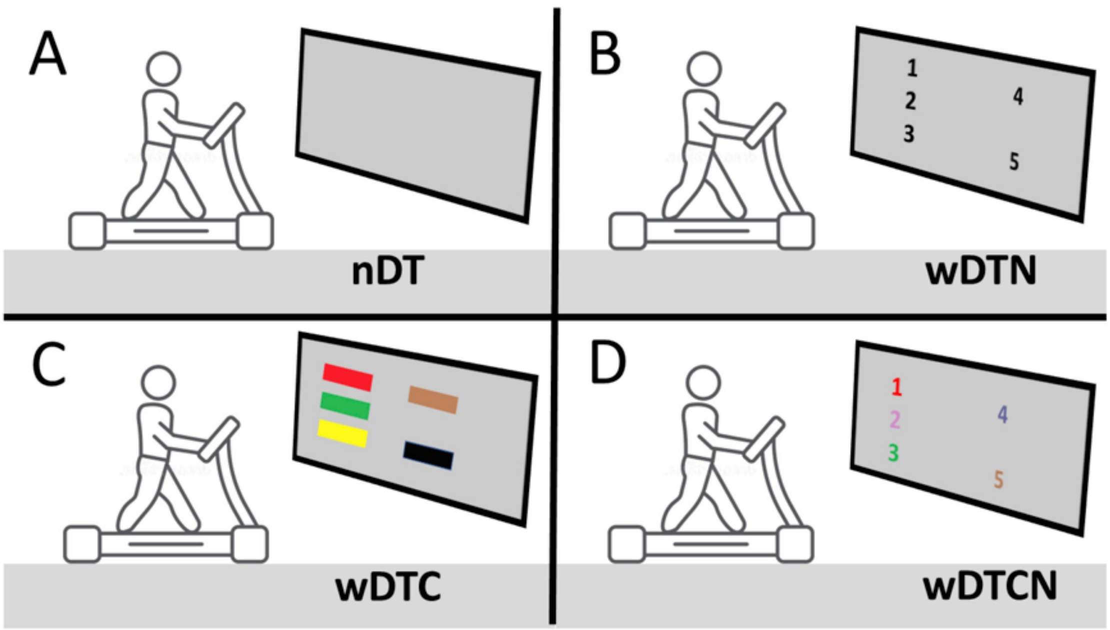
The functional mobility test (Time Up and Go Test - TUG) is characterized by a task, which starts in the sitting position in a standard chair with arms, the individual keeps the arms supported in the chair, gets up and walks three meters, turns, returns to the chair and sits down again. The time spent to complete the test is recorded , up to ten seconds being considered a normal time (for healthy): independent adults with no risk of falls; values between 11-20 seconds are expected for the elderly with disabilities or frail: with partial independence and low risk of falls; above 20 seconds suggests that the elderly has a significant deficit in physical mobility and risk of falls[15].

The Dynamic Gait Index (DGI) assesses patient's ability to modify the gait according to environmental changes. It consists of eight tasks that involve walking in different sensory contexts, as changes in speed, horizontal and vertical movements, climbing and down stairs. The maximum score corresponds to 24 points and values equal or below 19 points indicate instability in walking and a higher risk of falls[16].

Assessments

After the selection and characterization process, the same experimental protocols were applied for both groups. Four experimental conditions of 20 seconds each were used: Condition 1, treadmill gait with no dual task (nDT) (Figure 2A); Condition 2, treadmill gait with dual task - Number (wDTN) - the patient should walk on the treadmill while speaking a sequence of 30 items (numbers) projected in black color by the multimedia device, on a big screen (1.50 meters x 1.50 meters) positioned in front of the patient, in a random order that varied from number one to 11 (Figure 2B); Condition 3, treadmill gait with dual task - Color (wDTC) - the patient should walk on the treadmill while speaking a sequence of 30 items (colors) projected by the multimedia device in a random order that varied between 11 colors (red, light blue, dark blue, brown, purple, yellow, orange, green, black, pink and gray) (Figure 2C); Condition 4, gait with DT Color/Number (wDTCN) - the patient should walk on the treadmill while speaking a sequence of 30 items (numbers) projected in colored ink on the multimedia device in a random order ranging from number 1 (one) to 11, presented in 11 colors (red, light blue, dark blue, brown, purple, yellow, orange, green, black, pink and gray) (Figure 2D).

Figure 2. Treadmill gait conditions associated and not associated with the dual task. Figure 2A – treadmill gait with no dual task (nDT). Figure 2B - treadmill gait with DT Number (wDTN). Figure 2C – treadmill gait with DT Color (wDTC). Figure 2D - treadmill gait with DT Color/Number (wDTCN)



The cognitive task of the experimental protocol was based on the cognitive activities of the Stroop Test (ST) adapted for the illiterate which is presented in three parts (like the original), but with words being replaced by numbers[17].

For each part of the test, a total of 30 items (black and colored numbers and colors simbols) were used. For the participant was given 20 seconds to perform each part, advising him to carry out the task as fast as possible and identify the number and/or color, and named correctly. Thus, the variable referring to Stroop Test was computed: total number of Stroop Test (nST) – only correct answers - in each condition of Stroop Test (wDTN, wDTC and wDTCN).

The angular variables (total amplitude, maximum amplitude and minimum amplitude of the knee) were collected to improve the understanding of changes in gait during the experimental conditions of the study in both groups. These variables were collected by a Canon Vixia R800 Full Hd camera, positioned laterally to the treadmill, at a sampling frequency of 30 Hz. Three markers with diameters of 1.1 cm each were used, fixed on the right leg of the participant (on the greater trochanter of the femur, the lateral condyle of the tibia and the lateral malleolus of tibia).

After collection, the data were stored on a computer and processed by CVMob Software - Version 4.0 alpha (free version). The articular coordinates of movement were analyzed in the sagittal plane, considering ten cycles of gait, which produced ten paces. The knee extension was interpreted in this study as a value close to 180º of joint amplitude and flexion as a lower value. The range of motion of knee was calculated from the difference between the maximum and minimum ranges. The values of the angular variables of knee were calculated from the average obtained in ten paces.

The numbers and colors were presented using a Dell® portable projector Native resolution: WXGA (1.280 x 800) Colors displayed at 1.073 billion. The Treadmill used in the experimental protocol was the brand EMG System from Brazil Equipaments Ltda.®. The speed used by each individual was adjusted according to the patient and each condition was repeated three times to obtain a simple average.

The effects of dual task on treadmill gait in the various experimental conditions of were analyzed using relative measures (Double Task Effect - DTE), calculated from each study variable (range of motion, maximum and minimum amplitude movement), in a dual task condition and in a single task condition. A decrease under dual task conditions was represented by a negative value. An improvement in dual task conditions (that is, a double task benefit) was represented by a positive value (Eq. 1)[18].

$$\text{DTE } \{\%\} = \frac{\text{Dual Task Variable} - \text{Single Task Variable}}{\text{Single Task Variable}} \times 100 \tag{Eq. 1}$$

For variables in which the higher values indicate worse performance (instead of better) (example, knee joint amplitude), a negative sign was inserted in the formula (Eq. 2).

$$\text{DTE } \{\%\} = \frac{-(\text{Dual Task Variable} - \text{Single Task Variable})}{\text{Single Task Variable}} \times 100 \tag{Eq. 2}$$

Statistical analysis

The BioEstat version 5.3 software was used for data analysis. Data normality was assessed using the Shapiro–Wilk test and nonparametric tests. The Friedman Test was used to compare data for intragroup and Mann-Whitney Test for intergroup analysis, verifying the number of Stroop Test - nST (correct answers) during treadmill gait in the three conditions (wDTN, wDTC and wDTCN).

To observe Dual Task Effects on treadmill gait in conditions with no dual task (nDT) and with cognitive interference (wDTN, wDTC and wDTCN), the same tests were used for the intra-group evaluation (Friedman Test) and intergroup (Mann-Whitney Test). For all analyzes, a significance level of $p < 0.05$ was used.

Results

The study had a sample of ten individuals, five from Experimental Group and five from the Control Group. Each group was composed of three women (60%) and two men (40%). Table 1 presents the other demographic and clinical characteristics of the two groups studied.

Table 1. Demographic and clinical group characteristics

Variables	EXPERIMENTAL GROUP	CONTROL GROUP
	Average/Standart deviation	Average/Standart deviation
Age (years)	67.00 (53.00/67.00)	63.00 (53.00/67.00)
Height (m)	1.56 (1.56/1.61)	1.60 (1.56/1.63)
Body weight (kg)	66.80 (64.00/69.00)	71.00 (68.00/71.50)
Body Mass Index	26.30 (23.30/28.90)	27.90 (25.80/27.92)
Education (years)	4.00 (0.00/5.00)	1.00 (1.00/5.00)
UPDRS	53.00 (26.00/66.00)	-
H&Y	1.00 (1.00/2.50)	-
BBS	52.00 (50.00/54.00)	56.00 (56.00/56.00)
TUG	15.43 (14.79/15.74)	7.12 (7.03/7.32)
DGI	20.00 (20.00/21.00)	24.00 (24.00/24.00)

H&Y, modified Hoehn & Yahr Scale; UPDRS, Unified Parkinson's Disease Rating Scale ; TUG, Time Up and Go Test; DGI, Dynamic Gate Index; BBS, Berg Balance Scale.
*, significant difference between Control Group and Experimental Group (p<0.05).

According to the data presented in Table 1, the median of H&Y characterizes participants with PD in initial stage of the disease and the results of BBS indicate that these individuals are independent. In addition, the data referring to TUG determine that these participants are frail or dependent. Finally, DGI scores showed an absence of risk of falling. Thus, even in the case of a group of individuals in the initial state of PD, there is a difference between the scores when compared to the healthy elderly in the control group, especially in TUG, where they showed the greatest difference.

Demographic data did not show significant statistical differences between groups, as well as the balance measured. Unlike other clinical intruments (TUG and DGI) where we can observe a statistically significant difference between the groups studied, with the Control Group showing better results.

The data related to the number of Stroop Test (nST) during gait, performed in the three conditions, could be observed in table 2 that only within the Control Group there were significant differences between the conditions. Significant differences were also observed between groups, in the first two conditions (wDTN and wDTC).

Table 2. Data related to the number of correct answers in Stroop Test (nST) in both groups

Conditions	EXPERIMENTAL GROUP	CONTROL GROUP
	MEDIAN(1Q/3Q)	MEDIAN(1Q/3Q)
wDTN	17.0(16.0/24.0)[a]	28.0(28.0/29.0)[b]
wDTC	13.0(12.0/15.0)[c]	19.0(18.0/29.0)
wDTCN	14.0(13.0/15.0)	19.0(17.0/21.0)

nST, number of correct answers in Stroop Test; wDTN, with dual task – number; wDTC, with dual task – color; wDTCN, with dual task color/number.
[a], statistically significant difference in wDTN, between Experimental Group and Control Group; [b], statistically significant difference between wDTN and wDTCN in CG; [c], statistically significant difference in wDTC, between Experimental Group and Control Group; (p<0,05).

In Table 3, it is possible to observe the presence of significant differences between the CG and EG, in range of motion, in the conditions wDTN and wDTC. No statistical differences were found between the various conditions in the EG.

Table 3. Functional and articular variables of treadmill gait and the effect of the dual task

Variables/Condition	CONTROL GROUP						
	nDT	wDTN		wDTC		wDTCN	
	Values of single task	Values of dual task/Values of DTE (%)		Values of dual task/Values of DTE (%)		Values of dual task/Values of DTE (%)	
Range of motion	47.22±17.60	47.62±16.65	0.84[a]	43.87±11.70	-7.09[c]	49.54±3.47	4.91
Max. Range of motion	179.35±0.62	179.30±1.10	-0.02	179.48±0.55	0.07	179.68±0.13	0.18
Min. Range of motion	132.13±16.75	131.67±15.56	-0.34	135.60±11.17	2.62	130.13±3.51	-1.51
	EXPERIMENTAL GROUP						
	sDT	cDTN		cDTC		cDTCN	
Range of motion	50.65±9.60	45.67±10.69	-9.83[a]	46.02±14.43	-9.14[c]	46.20±12.32	-8.78
Max. Range of motion	176.13±5.63	176.19±4.65	0.03	176.35±1.98	0.12	179.62±0.51	1.98
Min. Range of motion	125.47±10.66	130.51±11.34	4.01	130.33±13.44	3.87	133.41±12.62	6.32

DTE, Dual Task Effects; wDTN, with dual task – number; wDTC, with dual task – color; wDTCN, with dual task color/number.
[a], statistically significant difference in wDTN, between EG and CG; [b], statistically significant difference in wDTC, between EG and CG; (p<0,05).

Discussion

The study analyzed the effects of the dual task interference on gait in individuals with PD, through the Stroop Test adapted for illiterates, and the results demonstrated that the performance of dual tasks (motor-cognitive) by individuals with PD interferes the performance of these individuals, where it was observed that motor task is prioritized.

The first result of our study shows how dual tasks interfere in joint amplitudes. In this study, when individuals with DP shows greater knee flexion (decrease in the minimum and in the maximum amplitude) than control group, in conditions that require more attention. These findings could be explained by the adaptive postural patterns of experimental group, which promote a flexible posture of the lower limbs and trunk[19].

In the present study a greater knee flexion was expected during the increase of attentional demands in the dual task conditions However, this fact is not reported. This can be explained with the fact that treadmill gait in PD improves joint stability and safety, and decreases the rate of co-contraction[20], by reducing the coactivation of flexors and extensors of the knee and ankle of patients with PD, but not in Control Group, suggesting a specific effect of the treadmill in PD[20].

The results also demonstrated the difficulty of individuals in switching attention between two simultaneous tasks, in order to hinder the processing of motor and cognitive information at the same time. In this situation, transferring attention from motor information (treadmill gait) to the cognitive task (adapted stroop test). In this study, is possible to assume that Experimental Group and Control Group prioritized the motor function, since the changes in cognitive activities were the most impaired (Table 2). Only in the Control Group there were significant changes in most of the experimental conditions of this study, thus the EG we can observe a decrease in the number of correct answers in the group with individuals with DP. This corroborates with previous studies, in which individuals with PD prioritized primary activity, in this case, treadmill gait[21]. The group composed of individuals with PD, we hypothesized that there was no significant difference during the dual task conditions, since it is a small group of participants who were in the initial stage of the disease.

However, other recent studies showed different results, where individuals with PD prioritized the cognitive task instead of maintaining the motor task performed. This difference between the findings can be explained by the dual task paradigm where the interference depends on the type of motor task6. In addition, gait is no longer considered just an automated motor activity6, and in PD patients there seems to be greater activation during normal gait on the ground than in healthy and older adults, also demonstrating greater brain activity during complex gait conditions, for example, when gait with obstacles[22,23]. Thus, other studies[24] suggest that cognitive control strategies may be different between gait modes (ground or treadmill), and that the influence of the modality on cognitive control should be considered when interpreting the effects of dual task.

Thus, there is a direct relation between cognition and gait, where cognitive processes are directly related to locomotion and the interference of the dual task can lead to impaired motor performance. Consequently, the choice of which cognitive interference should be offered in treadmill gait seems to have more clinical relevance. As we can see in the data related to the dual task conditions, in which the wDTC presented the same loss as the wDTCN in the number of correct answers, when we expected that the wDTCN was the one with the greatest attention demand, and consequently the one with the highest number of correct answers. This fact may be a consequence of the use of the protocol adapted for illiterates from the Stroop test.

Regarding the clinical data measured by TUG and DGI, a statistically significant difference was observed between the groups studied, with the CG showing better results. This result was already expected, considering that in PD there are motor impairments, such as bradykinesia, freezing, among others, which lead to changes in the locomotor profile of patients with PD, compared to the CG.

In addition, in PD there is a cognitive deficit that also directly interferes with motor performance. Thus, the inferior performance of the experimental group in the TUG, is in agreement with the previous results, where it was found that the variables of gender or age are considered together with the MCI (mild cognitive impairment), where it seems to intervene as a moderator of the performance of the TUG, suggesting that the MCI has an influence on the test, but not as an isolated variable[25]. Other studies have also found evidence of a strong relation between cognitive function and gait impairments, because they believe that gait involves several cognitive domains, such as executive-attentional function, visuospatial skills and even memory resources[10].

It is important to mention that there were no calculations of the effect of the double task in the variable number of correct answers, since this variable was not obtained in the single task condition of the Stroop Test. It is interesting to investigate whether the number of correct answers would be maintained or increased when individuals were placed only by performing the Stroop Test, since in all conditions, cognitive interference was associated with motor interference.

The gait associate with dual task can be another option in locomotor function training, in addition to providing a dual gait training with safety for PD patients. Thus, it is extremely important to explorer this theme in future works, considering that these variables are directly related to gait performance and the results of this study.

This study analyzed the effects of dual task in gait of individuals with PD, evaluating the number of correct answers in the Stroop Test associated with dual task. We believe it is relevant to develop new studies investigating the relationship between the number of correct answers in the Stroop Test when individuals were not exposed to more than one task, since all of our variables considered cognitive and motor interference simultaneously. In addition, as a limitation of the study, the small number of participants, where perhaps the results found do not represent the entire target population.

Conclusion

The results support the hypothesis that the dual task (motor-cognitive) associated with gait in individuals with PD interferes with the performance of these individuals. The findings reveal a greater impairment in cognitive function when compared to motor function (gait), since the results (number of correct answers) of the cognitive task were the most impaired.

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Author contributions

Araújo FR, Araújo DS and Cacho EWA participated in the conception, design, collection of research data, statistical analysis of research data, interpretation of results and writing of the scientific article. Gomes CLA participated in the statistical analysis of the research data, interpretation of the results and writing of the scientific article. Medeiros ALS participated in the statistical analysis of the research data and writing of the scientific article. Gondim ALM participated in the research data collection. Cacho RO participated in the interpretation of results and writing of the scientific article.

Competing interests

No financial, legal or political conflicts involving third parties (government, companies and private foundations...) have been declared for any aspect of the submitted work (including, but not limited to, grants and funding, participation in advisory council, study design, preparation of manuscript, statistical analysis...).

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