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Isokinetic muscle strength of knee extensors in individuals with parkinson's disease

Força muscular isocinética dos extensores do joelho em indivíduos com doença de Parkinson

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Abstract

Introduction: Despite tremor, bradykinesia, and rigidity are the classic motor symptoms of Parkinson's disease (PD), muscle weakness has also been pointed out as an important motor symptom associated to this disease, however, this condition is still poorly studied and the results are inconsistent. **Objectives**: This study aimed to compare the quadriceps muscle strength between individuals with PD and neurologically healthy individuals matched for age and gender. We also compared muscle strength in the limb more and less affected by the disease. **Materials and methods**: This study had the participation of 26 volunteers, 13 from the Parkinson group (64.08 ± 6.87 years; 73.82 ± 13.03 kg; 1.66 ± 0.07 m) and 13 from the control group (62.73 ± 6.42 years; 79.46 ± 11.40 kg; 1.71 ± 0.07 m). Peak Torque (PT) was measured in knee extensors using isokinetic dynamometry, at a velocity of 90°.s^{-1}. Student's t-test was used to compare average values intra- and inter-groups ($p < 0.05$). **Results**: Absolute PT was significantly lower in the Parkinson group (119.29 ± 40.06 N.m) when

compared to the control group (145.15 ± 20.05 N.m). Among individuals with PD we found significantly lower values of muscle strength in the more affected, when compared to the less affected limb (119.29 ± 40.06 N.m vs. 128.86 ± 35.56 N.m; p < 0.05). **Conclusion**: Based on the results, we conclude that patients with PD showed a decreased isokinetic PT in knee extensors, and these findings are exacerbated in the limb more affected by the disease.

Keywords: Parkinson's disease. Muscle strength. Torque. Isokinetic assessment.

Resumo

***Introdução**: Apesar do tremor, bradicinesia e rigidez serem os sintomas motores clássicos da doença de Parkinson (DP), a fraqueza muscular também tem sido apontada como um dos mais importantes sintomas motores associados a essa doença, porém, essa condição ainda é pouco estudada e os resultados são inconsistentes. **Objetivos**: O presente estudo teve o propósito de comparar a força muscular do quadríceps entre indivíduos portadores de DP e indivíduos neurologicamente saudáveis pareados por idade e gênero. Foi comparada também a força muscular do membro mais acometido e menos acometido pela doença. **Materiais e métodos**: Participaram deste estudo 26 voluntários, 13 do grupo Parkinson (GP: 64,08 ± 6,87 anos; 73,82 ± 13,03 Kg; 1,66 ± 0,07m;) e 13 do grupo controle (GC: 62,73 ± 6,42 anos; 79,46 ± 11,40 kg; 1,71 ± 0,07 m). Foi mensurado o pico de torque (PT) dos extensores do joelho por meio da dinamometria isocinética, na velocidade de 90°.s-1. Foi utilizado o teste t para comparar as médias intra e entre os grupos (p < 0,05). **Resultados**: O PT absoluto foi significativamente menor no GP (119,29 ± 40,06 N.m) quando comparado ao GC (145,15 ± 20,05 N.m). Entre os indivíduos com DP, foram encontrados valores significativamente inferiores de força muscular do membro mais acometido quando comparado com o menos acometido (119,29 ± 40,06 N.m vs. 128,86 ± 35,56 N.m; p < 0,05). **Conclusão**: Com base nos resultados, conclui-se que portadores da DP apresentam reduzido PT isocinético dos extensores do joelho, sendo esses achados exacerbados no membro mais acometido pela doença.*

***Palavras chave**: Doença de Parkinson. Força muscular. Torque. Avaliação isocinética.*

Introduction

Parkinson's disease (PD) is an idiopathic and progressive disorder which affects 1% to 2% of the world population > 50 years, and its main feature is the severe loss of dopaminergic neurons in the substantia nigra, which is related to somatic motor activity (1, 2). The classic symptoms are bradykinesia, tremor, and rigidity (3). However, muscle weakness in PD has gained attention among researchers and it has been pointed out as one of the most important motor symptoms (2, 4).

Recent studies, using sensitive equipment to assess muscle strength, have identified decreased strength in patients with PD when compared to control individuals, who are neurologically healthy (2, 5, 6). Furthermore, previous studies showed the relationship between muscle weakness and the decline in the basic and essential motor functions regarding the independence of these individuals, pointing out strength training as an important complementary approach (4, 7-10).

Berardelli et al. (11) indicates that muscle weakness occur as a secondary cause of bradykinesia (11). However, despite these indications, there are still many doubts with regard to the muscle strength behavior of individuals affected by PD, when compared to neurologically healthy individuals of the same age and gender (10). There are few studies which quantified muscle strength in PD and the results found are inconsistent (12). The specific cause of a possible strength deficit in these subjects is not known, yet, and it is still a matter of debate if it is of a central or peripheral origin, as well as if it is inherent to the disease or secondary to an external phenomenon.

In an attempt to shed some light on this issue, some authors also evaluated the difference in strength between the limb more affected, when compared to the less affected, by the disease, however, the results are controversial. Nogaki et al. (13) evaluated the isokinetic strength of knee extension and flexion in patients with PD, at three different velocities, and it compared the strength of limbs. Peak Torque (PT)

was significantly lower in the more affected limb only at the velocities of 90°.s^{-1} and 180°s^{-1}, with no difference at the velocity of 30°.s^{-1}. On the other hand, Inkster et al. (14) evaluated the PT of knee extension in both limbs of individuals with PD, at the velocity of 45°.S^{-1}, and found no difference between the more affected when compared to the less affected leg. Malicka et al. (15) evaluated the isokinetic strength in the quadriceps at higher velocities and it also identified no difference between the more affected and the less affected leg among subjects with PD.

Whereas the comparison of muscle strength between patients with PD and neurologically healthy individuals, as well as the evaluation of muscle strength among patients with PD, has been poorly documented, and taking into account that the results are controversial, there is a need for conducting further studies in order to explain how much of the strength loss is a result of natural aging and how much is a result of PD. Thus, this study aimed to compare the isokinetic muscle strength of quadriceps between individuals with PD and neurologically healthy subjects, matched for age and gender, as well as compare the muscle strength of the more affected to the less affected limb in individuals with PD.

Materials and methods

Subjects

This study was approved by the Research Ethics Committee of the Federal District Health Council, under the Protocol 034/11, and the participants confirmed their participation in the investigation by signing a free and informed consent term; 26 subjects volunteered for the study, and 2 groups were formed.

The Parkinson group (PG) consisted of 13 male individuals recruited at the Parkinson's Outpatient Ward of the the Federal District Base Hospital, with diagnosed PD in accordance with the Criteria of the Brain Bank of London and rated between 1 and 3 in the modified stage scale of the disease proposed by Hoehn and Yahr (H & Y) (16). The control group (CG) consisted of 13 subjects matched for gender and age, with no neurological disease and apparently healthy.

The inclusion criteria were: 1) age between 50 and 75 years; 2) individuals who were not involved in strength training in the last 6 months; 3) no significant health problems and/or disability which could be aggravated due to the experimental protocol; 4) individuals with PD who have shown no cognitive deficits, according to the Mini-Mental Status Examination (MMSE) score, i.e. ≥ 24 points for literate or ≥ 17 for illiterate individuals (17, 18); 5) no other neurological disease in PG or any other condition limiting the ability to complete the study protocol.

Physical activity level

The physical activity level was determined by applying the International Physical Activity Questionnaire (IPAQ). The model used in this study corresponds to the official translation into Portuguese of the short version, previously validated for the Brazilian population (19). In order to categorize the results, we divided it into 2 groups: 1) insufficiently active; and 2) active (20).

Isokinetic torque peak

The quadriceps strength was measured using the isokinetic dynamometer Biodex System 3 (Biodex Medical System, New York, USA), calibrated according to the manufacturer's guidelines. After a detailed explanation of the evaluation, volunteers were carefully positioned on the device seat. The rotation axis of the dynamometer arm was aligned to the lateral femoral epicondyle. The force application site was positioned around 2 inches away from the medial malleolus. The belts were fastened with velcro on the trunk, pelvis, and thigh in order to avoid possible compensatory movements. After heating on the equipment, the protocol consisted of 3 series of 10 concentric muscle contractions for bilateral knee extension, at the velocity of 90°.s^{-1}. We asked the volunteers to perform the test with the greatest vigor possible and verbal encouragement was used throughout the measurement. They reported which lower limb was more affected by the disease only in the day of assessment, which was carried out at the "on" phase, i.e. between 1 and 2 hours after the use of medication. The amount recorded for subsequent analysis was the highest PT in the 3 series, which was expressed in absolute values (N.m) and in values related to body mass (N.m/kg^{-1}).

For an analysis among the individuals in PG, we took into account data on the PT of the limb more affected and less affected by the disease. For an analysis between groups, we used the PT values of the limb more affected in PG and the right lower limb of CG. This choice was based on previous studies which found no isokinetic differences between the dominant and non-dominant lower limbs in untrained individuals (14, 21).

Statistical analysis

We applied the Shapiro-Wilk normality test to all variables. For comparing the groups with regard to demographic characteristics, we employed Student's t-test in cases where the variables had a Gaussian distribution. In cases where there was no normality in both groups, we used the non-parametric Mann Whitney test. For comparing the average values between groups, we used Student's t-test. For comparing the average values between the more affected and the less affected limb in PG, we used Student's t-test for dependent samples. The significance level was $p < 0.05$. Data were analyzed by means of the software *SPSS*, version 17.0.

Results

Considering the average values and the standard deviation of the sample characteristics, there was no statistically significant difference between these groups with regard to age, body mass, height, and body mass index (BMI). In the assessment of disease severity according to the modified H & Y scale, 3 subjects were classified into 3 and most of them into 2. The results of the IPAQ in PG showed that 84.6% were regarded as active and 15.4% as insufficiently active. In CG, 61.5% were regarded as active and 38.5% as insufficiently active (Table 1).

The isokinetic PT of individuals from PG and CG are shown in Graphs 1 and 2. The absolute PT of quadriceps was significantly lower in individuals with PD when compared to CG. However, this difference did not reach statistical significance for PT with regard to body mass.

When comparing muscle strength in the quadriceps between individuals from PG, both the PT in absolute values and in values related to body mass were significantly lower in the limb more affected when compared to the limb less affected by the disease (Graphs 3 and 4).

Discussion

The isokinetic dynamometer has been widely used to assess the muscle strength of elderly individuals both in clinical practice and in research protocols (22). Although the amount of references available is still restricted, there is a growing number of studies using this device to investigate the strength of different muscle groups in individuals with PD (2, 5). In this study, the results of PT assessment in the isokinetic dynamometer showed a significant difference in quadriceps strength in individuals with PD, when compared to subjects without the disease matched for age and gender, corroborating previous studies (5, 14). Durmus et al. (5) assessed the PT in quadriceps at 3 velocities ($90°.s^{-1}$, $120°.s^{-1}$, and $150°.s^{-1}$) and it observed that muscle weakness in individuals with PD does not depend on velocity (5). Although evidence points out weakness as a characteristic of PD, the origin of this strength deficit has been put into question, whether peripheral or central, whether inherent to the disease or deriving from external factors.

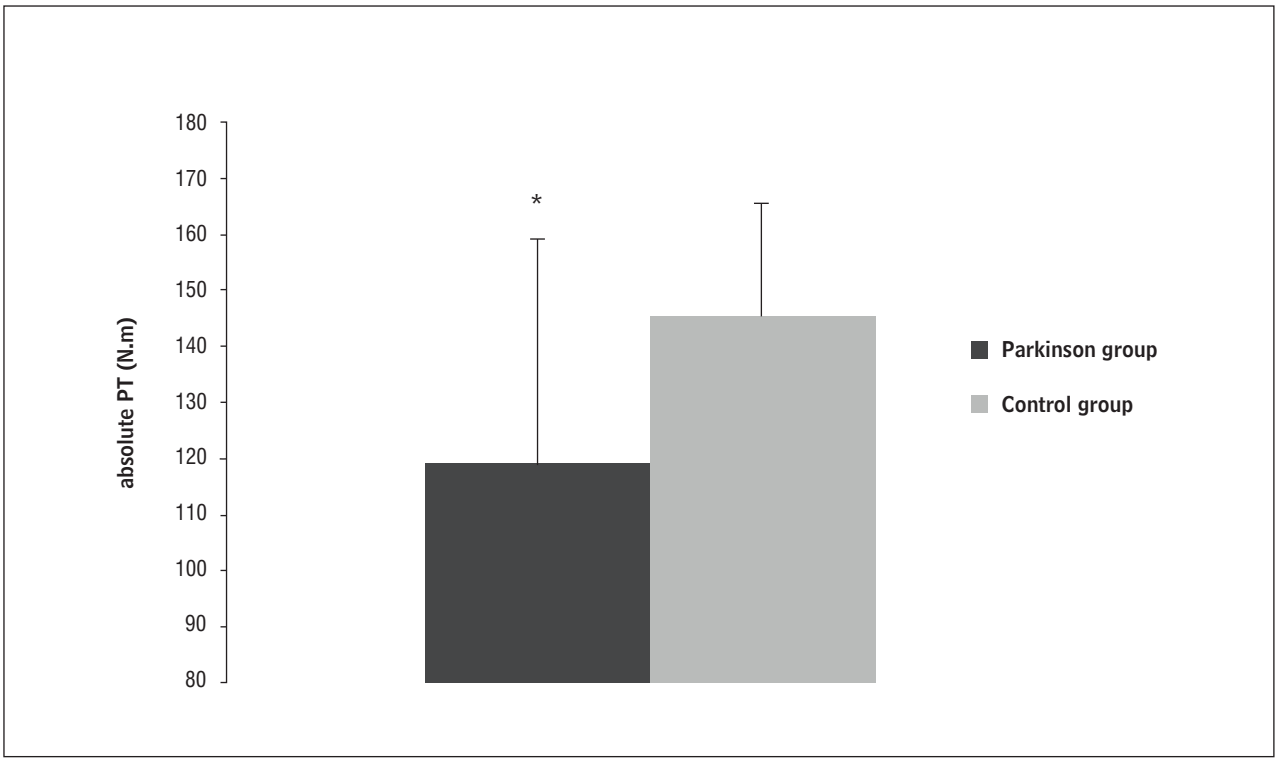
Among the external factors, the level of usual physical activity practice seems to be important information in researches assessing muscle strength in PD, since some studies show that individuals with PD have a lower level of physical activity and, thus they would be more exposed to the deleterious effects of immobility (23). However, studies taking into account the physical activity level in the assessment of muscle strength in PD are still rare, it was reported by only one research (14). In this study, most participants from PG (84.6%) were regarded as physically active. This suggests that the lower ability to generate torque in PD may be mainly derived from changes in the central nervous system and not from physical inactivity. Nevertheless, the physical activity level was assessed by means of a questionnaire, therefore, the theme requires further investigation.

While some authors assessed strength during the "on" and "off" disease periods, this study was conducted only during the "on" disease period, in order to determine PT in the best motor status,

Table 1 – Characteristics of participants (average values ± standard deviation)

	PG (n = 13)	CG (n = 13)	P - value
Age (years)	64,08 ± 6,87	62,73 ± 6,42	0,621
Body weight (kg)	73,82 ± 13,03	79,48 ± 11,40	0,130*
Height (m)	1,66 ± 0,07	1,71 ± 0,07	0,091
BMI (kg/m2)	26,76 ± 4,15	27,19 ± 2,56	0,754
Time of Diagnosis (years)	5,5 ± 3,01		
H&Y	2,3 ± 0,48		
PAL			
Active	11	8	
Insufficiently active	2	5	

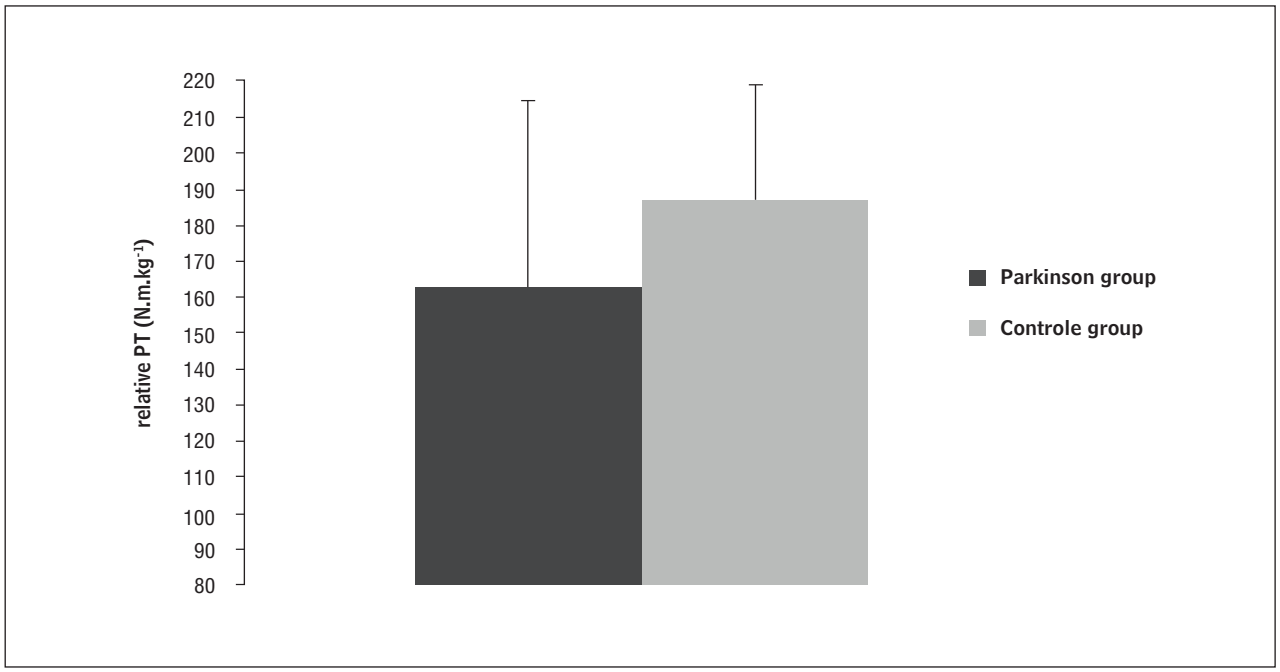
Legend: * = result of the Mann Whitney test; H & Y = Hoehn and Yahr (modified scale); PAL = physical activity level
Source: Research data.



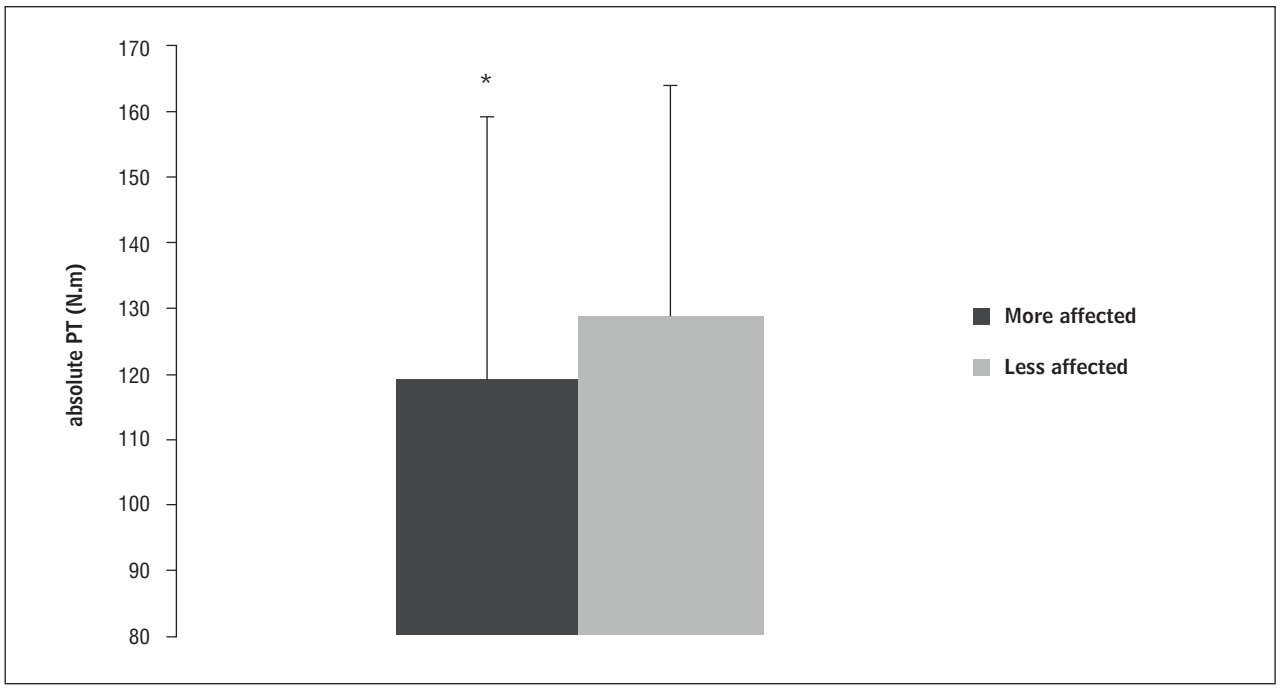
Graph 1 - Absolute peak torque (absolute PT) in the groups under assessment
Legend: * = significantly different when compared to Control Group ($p < 0.05$).
Source: Reseach data.

when it is expected that the patient spends most of her/his day with the treatment, including the practice of physical exercise (4, 5, 24, 25). Thus, the differences in PT found between the groups, even with a mild to moderate severity level (average of 2.3) and with the positive effect of anti-Parkinsonian drugs on motor performance, emphasizing that muscle weakness seems to be a clinical manifestation influenced by central changes caused by the disease.

The basal ganglia are a group of neuronal nuclei, located at the bottom of the brain, which are part of a complex network of circuits, including the motor circuit, the latter being responsible for planning and

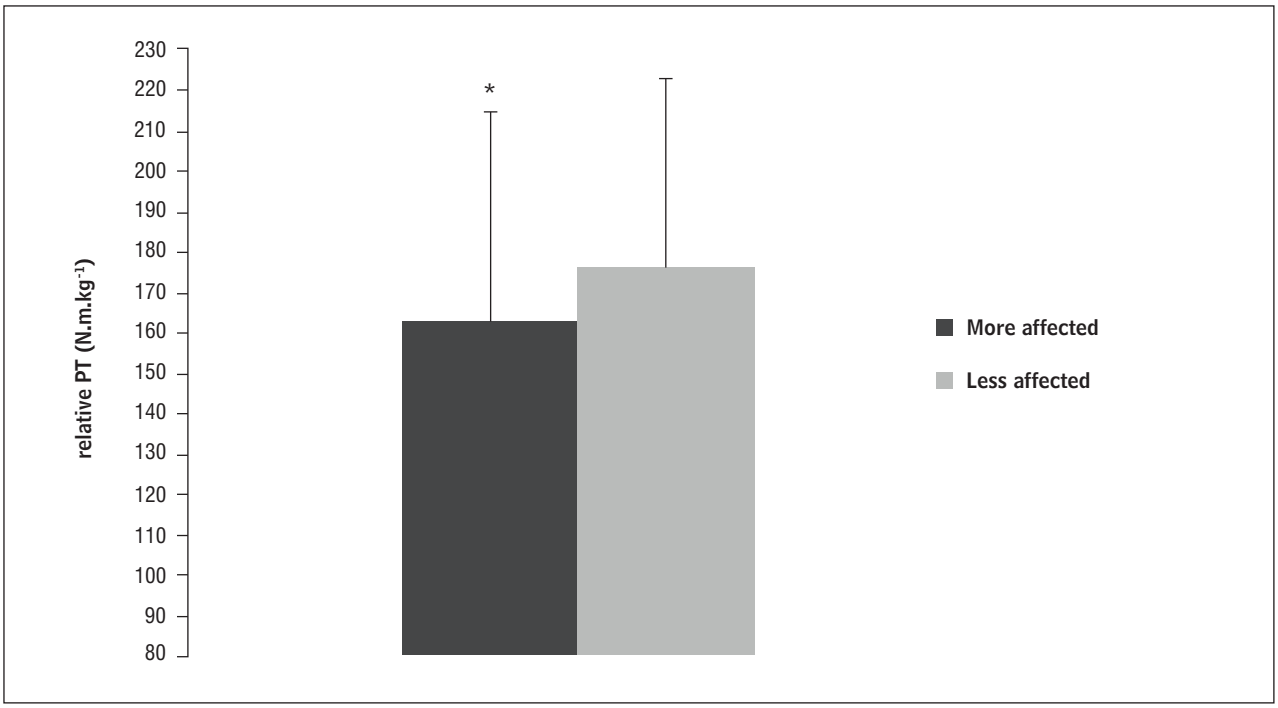


Graph 2 - Relative peak torque (relative PT) in the groups under assessment
Source: Research data.



Graph 3 - Absolute peak torque (absolute PT) in the more affected and less affected limb in PG
Legend: * = significantly different with regard to the less affected limb ($p < 0.05$).
Source: Research data.

sequencing the individual's motor acts. In PD, projections deriving from the motor areas of the cerebral cortex towards the striatum, one of the neuronal groupings of the basal ganglia, are changed due to the decreased release of dopamine from the substantia nigra. Changes in neural conduction at the cortical



Graph 4 - Relative peak torque (relative PT) in the more affected and less affected limb in PG
Legend: * = significantly different with regard to the less affected limb ($p < 0.05$).
Source: Research data.

and striated pathway lead to a sequence of disarrangements in the other pathways of the basal ganglia, causing dysfunctions in motor responses (26). Thus, in PD, the disturbances occurring in the basal ganglia compromise the efferent pathway and they can cause a decreased activation of motor units and, as a consequence, deficit in the production of muscle torque, as observed in this study.

It is also worth stressing that the disorders affecting the basal ganglia generate disturbances in thalamic connections to the prefrontal cortex and in the limbic integration for voluntary activities, with the possibility to cause an increase in perceived effort, lack of motivation, and difficulty for performing activities (27). These symptoms, characteristic of central fatigue, are often observed in individuals with PD (28) and, although not evaluated in this study, they can exert influence on the muscle strength deficits observed among this population.

By comparing the average values of PT between the two limbs in PG, the PT of the more affected limb was significantly lower. This result was found in previous studies (5, 6, 13). However, some authors found out that this difference in strength is dependent on velocity and that at velocities < 90°.s^{-1} there is no distinction in PT between limbs (6, 13). For instance, Inkster et al. (14) found no difference between limbs at the velocity of 45°.s^{-1}; Malicka et al. (15) assesed the PT of a bilateral knee extension at 60°.s^{-1} and 180°.s^{-1}, and even at higher velocities, and it did not identify any difference between limbs more and less affected by the disease.

Although the results of this study show differences between limbs in terms of PT, it is believed that there is a manifestation of the bradykinesia sign in isokinetic tests at higher velocities, with the possibility of interfering with strength production, decreasing the PT generated (29). Moreover, it has been already proved in the literature that the higher the isokinetic velocity applied, the lower the ability to generate torque, both in adults and in elderly individuals (30).

Conclusion

Having the results observed as a basis, we conclude that patients with PD have a significantly lower PT when compared to neurologically healthy individuals matched for age and gender. Moreover, it was observed that, at the velocity under assessment, muscle weakness is exacerbated in the limb more affected by the disease.

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