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Association between functional balance and knee extensors strength in people with Parkinson's disease

Associação entre o equilíbrio funcional e a força dos extensores do joelho em pessoas com a doença de Parkinson

Asociación entre el equilibrio funcional y la fuerza de los extensores de la rodilla en personas con la enfermedad de Parkinson

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ABSTRACT

AIMS: The aim of this study is to verify if there is a correlation between functional balance and muscular strength of knee extensors in individuals with Parkinson's disease.

METHODS: The sample consisted of 28 volunteers with Parkinson's disease (age: 65.43 ± 8.48 years, height: 1.68 ± 0.10 cm, weight: 71.50 ± 13.27 kg) classified on the modified Hoehn & Yahr scale. The Four Step Square Test and the isokinetic dynamometer were used to evaluate the dynamic balance and muscular strength of knee extensors, respectively.

RESULTS: The peak torque shows a moderate, negative and significant correlation with the Four Step Square Test (right knee: $r = -0.471$ and $p = 0.012$; left knee: $r = -0.444$ and $p = 0.018$).

CONCLUSIONS: There is a negative, moderate and significant association between muscular strength of knee extensors and dynamic balance in Parkinson's disease individuals.

KEYWORDS: Muscle Strength Dynamometer; Neurotransmitter Agents; Nerve Degeneration; Substantia Nigra; Activities of Daily Living.

RESUMO

OBJETIVOS: O objetivo deste estudo é verificar se há correlação entre o equilíbrio funcional e a força muscular de extensores de joelho em indivíduos com doença de Parkinson.

MÉTODOS: A amostra consistiu de 28 voluntários com a doença de Parkinson (idade: $65,43 \pm 8,48$ anos; estatura: $1,68 \pm 0,10$ cm; peso: $71,50 \pm 13,27$ kg) classificados na escala de Hoehn & Yahr modificada. O Four Step Square Test e o dinamômetro isocinético foram utilizados para avaliar o equilíbrio dinâmico e a força muscular dos extensores do joelho, respectivamente.

RESULTADOS: O pico de torque mostra uma correlação moderada, negativa e significante com Four Step Square Test (joelho direito: $r = -0,471$ e $p = 0,012$; joelho esquerdo: $r = -0,444$ e $p = 0,018$).

CONCLUSÕES: Há uma associação negativa, moderada e significativa entre a força muscular de extensores de joelho e o equilíbrio dinâmico em indivíduos com doença de Parkinson.

PALAVRAS-CHAVE: Dinamômetro de Força Muscular; Neurotransmissores; Degeneração Neural; Substância Negra; Atividades Cotidianas.



RESUMEN

OBJETIVOS: El objetivo de este estudio es verificar si hay correlación entre el equilibrio funcional y la fuerza muscular de extensores de la rodilla en individuos con la enfermedad de Parkinson.

MÉTODOS: La muestra consistió de 28 voluntarios con la enfermedad de Parkinson (edad: $65,43 \pm 8,48$ años; estatura: $1,68 \pm 0,10$ cm; peso: $71,50 \pm 13,27$ kg) clasificados en la escala de Hoehn & Yahr modificada. El Four Step Square Test y el dinamómetro isocinético fueron utilizados para evaluar el equilibrio dinámico y la fuerza muscular de los extensores de la rodilla, respectivamente.

RESULTADOS: El pico de torque muestra una correlación moderada, negativa y significativa con el Four Step Square Test (rodilla derecha: $r = -0,471$ y $p = 0,012$; rodilla izquierda: $r = -0,444$ e $p = 0,018$).

CONCLUSIONES: Hay una asociación negativa, moderada y significativa entre la fuerza muscular de extensores de rodilla y el equilibrio dinámico en individuos con la enfermedad de Parkinson.

PALABRAS CLAVE: Dinamómetro de Fuerza Muscular; Neurotransmisores; Degeneración Nerviosa; Sustancia Negra; Actividades Cotidianas.

INTRODUCTION

Parkinson's disease (PD) is a neurodegenerative disease characterized by progressive deterioration of the substantia nigra in the midbrain which causes a decrease in dopamine production¹. Because of this brain change, people with PD may have motor deficits in posture and balance, including bradykinesia, hypokinesia, gait freezing, stiffness, tremors, and instability². Moreover, some studies report a deficit of muscular strength in people with PD when compared to neurologically healthy groups^{3,4}.

The weakness regarding PD may result from both central and peripheral factors, affecting both the process and the send of information, in addition to the movements execution⁵. Hence, this muscle weakness tends to compromise the ability to perform activities of daily living as well as the increased risk of falls⁶. Furthermore, individuals with PD have balance flaw, a common feature that favors autonomy loss².

Deterioration of the basal ganglia produces an increased inhibitory pattern, causing difficulties in modulating the balance strategies⁷, because of these changes, individuals with PD tend to shift the gravity center to forward⁸. As a result of these conditions, is impossible for a person with PD to plan and execute compensatory movements to recover balance and stability, which may lead to falls⁹.

The literature reports that strength is related to mobility for people with PD⁶, however, most of the studies are performed with computerized posturography¹⁰⁻¹², which most clinics and training centers do not have access. Thus, there is need to study dynamic balance and its relationship with strength, through a test with low cost, easy reproducibility and with the possibility of diversified movements (x and y axis), that imitate day-to-day actions and allow greater security for the people with PD.

The Four Step Square Test (FSST) is a functional balance test which demands a subject to move sideways, forwards and backwards overcoming obstacles in a specified sequence, moreover to apply the test only 4 canes and one stopwatch are required¹³. Thus, it increases the applicability of the test, already being used in different populations, such vestibular disorders¹⁴, stroke¹⁵ and PD¹⁶.

Studies report an increase in muscle strength as a result of an adequate training program^{17,18}, which lead effectively to improve physical capabilities¹⁹, including balance²⁰. Moreover, the PD deficits can cause loss of mobility and the influence on strength². Thus, the aim of this study is to verify if there is a correlation between functional balance and muscular strength of knee extensors in individuals with PD.

METHODS

The sample consist of 28 individuals with a clinical diagnosis of PD, they were classified on the modified Hoehn & Yahr scale²¹. The volunteers were instructed not to perform physical exercises on 24 hours prior to the tests protocols. The Mini Mental State Examination was used to screen for mild cognitive impairment of participants and the criterion for inclusion in the study was established as a score >24 points²². As the test is influenced by educational level, inclusion scores were adjusted to >19 points for illiterate individuals²³.

The subjects needed to visit laboratory 2 times, with 48 hours of interval, first for anthropometric measurements, anamnesis and strength test, and second for functional test. All the participants were evaluated in "on" medication period, and this study was approved by the Faculty of Health Sciences at University of Brasilia ethics committee (number: 79851717.2.0000.0030) and all volunteers signed the consent form.

The level of physical activity was measured using the International Physical Activity Questionnaire (IPAQ) and the model used was the short version. In order to classify the obtained results, the division into four groups was used: 1) very active; 2) active; 3) insufficiently active; 4) sedentary²⁴.

To assess dynamic balance the FSST was used, the volunteer starts on square 1 and is required to step as fast as possible into each square in the following sequence: 2, 3, 4, 1, 4, 3, 2, and 1 (**Figure 1**). The researcher performed the test once as a demonstration and the volunteer performed a sequence for familiarization. Two trials were performed and the fastest time was used²⁵.

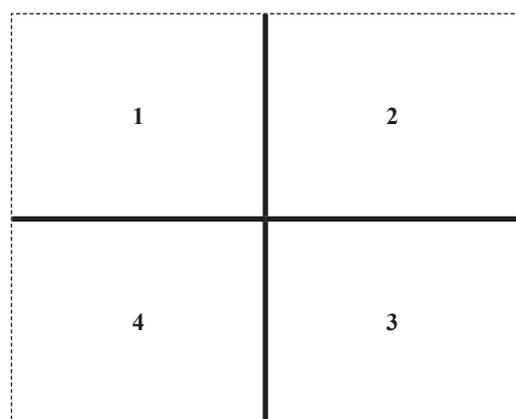


Figure 1. Four Step Square Test.

To assess muscular strength of knee extensors the Biodex system III Isokinetic Dynamometer (Biodex Medical, Inc., Shirley, NY) was used with the protocol adapted from Malicka et al.²⁶ and were performed only in the concentric phase. Moreover, all the warm-ups and trials had 60 seconds of rest interval. The participants performed 2 trials on each leg and the protocol was counterbalanced.

Warm-up: 1 set of 10 repetitions at 180°/s as follows, was ordered for the volunteer to do one maximum contraction, and then it was ordered to do 9 more contractions between 50% and 60% of the maximal effort. Test: 2 sets of 4 repetitions at 60°/s. The trial with the highest value was used to determine the absolute torque peak (PT).

For sample characterization, descriptive statistics were performed with mean and standard deviation for quantitative variables, and simple frequency for qualitative variables. To verify data normality the Shapiro-Wilk test was used. The Pearson correlation of the functional balance and muscular strength of knee extensors was performed. The statistical significance level was set at $p < 0.05$ in all correlations.

RESULTS

Sample characteristics are described in **Table 1**.

Table 1. Sample characterization.

	Mean ± Standard Deviation
Age (year)	65.43±8.48
Weight (kilogram)	71.50±13.27
Height (meter)	1.68±0.10
FSST (second)	9.41±1.62
PT right side (Newton.meters)	131.80±47.85
PT left side (Newton.meters)	122.99±44.08
Gender (frequency)	
Men	20
Women	8
Hoehn & Yard (frequency)	
Level 1	3
Level 1.5	4
Level 2	9
Level 2.5	8
Level 3	4
IPAQ (frequency)	
Very active	3
Active	14
Insufficiently active	7
Sedentary	4

IPAQ: International Physical Activity Questionnaire; FSST: Four Step Square Test.

Figure 2 shows correlation between functional balance with muscular strength of knee extensors (right knee: $r = -0.471$ and $p = 0.012$; left knee: $r = -0.444$ and $p = 0.018$), and all correlations are significant, $p < 0.05$. The PT shows a moderate, negative and significant correlation with the FSST (**Figure 2**).

DISCUSSION

The objective of this study was to verify if there is a correlation between functional balance and muscular strength of knee extensors in individuals with PD, and we observed that subjects who demonstrated higher PT, also performed the faster FSST test. Thereby, the FSST is a predicted risk of falls²⁷ and the strength maybe help it. Predict risk of fall is important for this population because, in addition to the motor changes caused by disease², the aging process increases this risk²⁸.

Taking into account that most falls happen while execution of dynamic tasks²⁹, and people with PD may have symptoms that limit walk such gait freezing², which combined with decreased of lower limb muscle strength³⁰ can improve balance disorders, thus

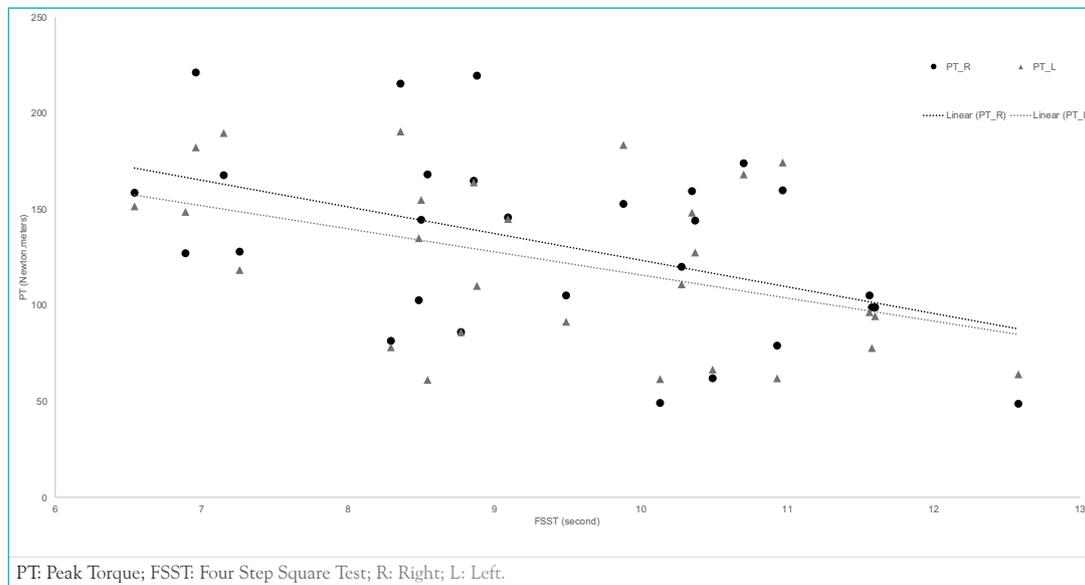


Figure 2. Correlation between FSST and PT.

emphasizing the importance of strength training³¹. The lower limb muscle strength has an important effect on the mobility helping the postural instability caused by the PD manifestations³⁰.

Studies show that strength and resistance training improve balance in this population^{32,33}, but few studies show an association between this physical capabilities, and less studies show this association with a simple and reliable test. This association can be explained due for production of movements is necessary a muscular contraction mediated by the somatic nervous system, as well as to develop strength³⁴.

There are a few limitations associated with the present study. The first limitation is the small sample size which reduces the statistical power and reduces the generalizability of our findings. The second is not split individuals by stages of the modified Hoehn and Yahr scale neither gender. The third limitation is not considered the level of physical activity. Future studies could analyze each gender, stages of the modified Hoehn and Yahr scale and level of physical activity separately, besides increasing the sample size, moreover investigate in relation to laterality, the most affected side by the disease and to evaluate this population in the “off” medication period.

CONCLUSION

There is a negative correlation between functional balance and muscular strength of knee extensors in individuals with PD. For practical applications, the FSST can be used as a predictor of muscle strength decrease, as well as an alert for possible falls.

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