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Original Article

PREDICTORS OF THE FUNCTIONAL REACH TEST IN PEOPLE WITH PARKINSON'S DISEASE

PREDITORES DO DESEMPENHO NO TESTE DE ALCANCE FUNCIONAL EM PESSOAS COM DOENÇA DE PARKINSON

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RESUMO

A instabilidade postural, um sinal/sintoma cardinal da doença de Parkinson (DP), é caracterizada pela associação entre alinhamento postural, amplitude de movimento e rigidez muscular. O objetivo foi analisar a relação entre o desempenho no teste de alcance funcional (TAF) e fatores relacionados a amplitude de movimento e aspectos clínicos da doença. Participaram 25 pessoas com DP nos estágios 1,0 e 1,5 da Hoehn e Yahr. As variáveis dependentes analisadas foram: desempenho no TAF e as pontuações nos itens da avaliação clínica da *UnifiedParkinson'sDisease Rating Scale*: teste de retropulsão, rigidez muscular e condição motora. A distância média no TAF foi de 25,3 cm e o deslocamento anteroposterior médio do centro de pressão foi de 2,69 cm. A amplitude de movimento articular do tornozelo está associada ao desempenho no TAF, enquanto a estabilidade postural está associada ao deslocamento anteroposterior do centro de pressão durante o TAF. Conclui-se que o desempenho no TAF em pessoas com DP é determinado pelo nível individual de equilíbrio e pela amplitude articular do tornozelo e a rigidez muscular e alterações funcionais do envelhecimento são responsáveis pelo desempenho no TAF.

Palavras-chave: Equilíbrio postural. Doença de Parkinson. Rigidez muscular.

ABSTRACT

Postural instability, a fundamental signal/symptom of Parkinson's disease (PD), is characterized by the association between postural alignment, joint range of motion, and muscular rigidity. The aim of the present study was to analyze the relationship between performance in the functional reach test (FRT) and associated factors such as joint range of motion and PD clinical features. Twenty-five people with PD in stages 1 and 1.5 of the Hoehn & Yahr scale participated in the study. The analyzed dependent variables were: FRT performance and scores in the items of clinical evaluation of the Unified Parkinson's Disease Rating Scale: pull-test, motor rigidity, and motor condition were used. The average distance in the FRT was 25.3 cm and the mean anterior-posterior displacement of the center of pressure was 2.69 cm. The ankle range of motion was associated with FRT performance, while postural stability was associated with the anterior-posterior displacement of the center of pressure during the FRT. We conclude that FRT performance in people with PD is determined by the individual level of balance and by the ankle joint amplitude and muscular rigidity and functional alterations due to aging are responsible for FRT performance.

Keywords: Postural balance. Parkinson's disease. Muscular rigidity.

Introduction

Parkinson's disease (PD) is a chronic and progressive neurological disorder, associated with functional decline[1,2]. Currently, it is the second most prevalent neurodegenerative disorder in the world, affecting 0.5 to 1% of the population aged 65-69 years, with an increasing prevalence with age, reaching 3% in the population aged 80 years[3-5]. In Brazil, epidemiological data indicate that 3.3% of the Brazilian population over 64 years of age is affected by the disease [6].

PD is due to the progressive death of the dopaminergic neurons of the substantia nigra, which causes motor and cognitive impairments that reduce functionality. It is characterized by the presence of motor tremors at rest, joint stiffness, bradykinesia, and postural instability[1,2,7]. Postural instability represents one of the most disabling motor symptoms of PD, being one of the main risk factors for falls[8,9].

Changes in the postural stability of people with PD are multifactorial[9] and characterized by the association between the factors: postural alignment, range of motion, and joint stiffness[10,11]. The postural characteristic of this population, stooped posture, marked by flexion of trunk, hip, and knees, has been attributed to muscle and joint stiffness. Stooped posture reduces range of motion, implying inflexibility of reactive postural responses, such as lower hip and knee movement during an external disturbance, and may increase the occurrence of falls[11,12]. Furthermore, other factors are associated with postural instability and related to disease progression, such as the clinical aspects assessed by the Unified Parkinson Disease Rating Scale (UPDRS - gold standard scale for PD), among them motor impairment (motor subscale), postural stability (retropulsion test), and muscle stiffness, as previously mentioned[13,14], besides staging of the disease evaluated by the Hoehn & Yahr scale.

The Functional Reach Test[15,16] is a widely applied clinical trial, recommended for assessing postural stability in people with PD. This test measures the anteroposterior stability by means of the distance in centimeters that the person can reach to the front while standing[17]. During the test, the position of the center of pressure (CoP) is usually measured by posturography[18]. Posturography provides accurate indicators of dynamic balance, such as the antero-posterior displacement of CoP, which are not obtained through clinical examination[19] and where the excursion of the CoP is associated with falls and physical fragility[20,21]. However, the mentioned factors have been little considered in the relationship and prediction of performance in the functional reach test in patients with PD. Clarification of the relationship between factors associated with range of motion and clinical aspects and, mainly, prediction of the functional reach test, could guide the evaluation process, clinical practice, and interventions for this population, since the functional range test is easily applicable in clinics and provides parameters for interpreting and monitoring instability.

Some studies have observed that rigidity has an important relation with the performance of postural control [22,23]. The study of Rocchi et al.[22] observed that patients with the predominant motor symptom of rigidity presented worse performance in some situations of postural control. Therefore, range of motion is expected to be closely related and capable of predicting performance in the functional reach test, with emphasis on the other clinical aspects.

Thus, the objective of this study was to analyze the relationship between performance in the functional reach test (maximum distance of antero-posterior displacement of the CoP) and factors related to range of motion (trunk, hip, knee, and ankle) and clinical aspects of the disease (postural stability, motor impairment, joint stiffness, and staging of the disease).

Methods

Participants

Twenty-five people with idiopathic PD were recruited for this study, selected through the database of the Laboratory of Posture and Locomotion Studies (LEPLO) at the Júlio de Mesquita Filho State University (UNESP). Of the 250 entries in the database, 70 were available and of these, 25 patients met the following inclusion criteria: disease stage of 1 or 1.5 on the Hoehn & Yahr scale (H & Y) - representing the degree of disease involvement[24]; absence of other neurological, osteoarticular and vestibular disorders or other pathologies that

did not allow the task to be performed. All participants were aware of the study, agreed, and signed the Informed Consent Form approved by the local ethics committee (protocol 3936, 05/06/2012).

Procedures

Initially, demographic (age and gender) and anthropometric data (weight and height) were obtained. Subsequently, the range of joint motion was measured by means of a fleximeter (measured in degrees). Measurement of trunk flexion was performed with the person standing, and hip flexion and hyperextension, and knee hyperextension in dorsal decubitus, and ankle plantar flexion and dorsiflexion in the sitting position[25].

The *Unified Parkinson Disease Rating Scale* (UPDRS)[26] was used to evaluate the disease involvement. The UPDRS is subdivided into three subscales: I - Mental state, mood and behavior, II - Activities of daily living, and III - Motor examination. The UPDRS item 30, retropulsion test, which evaluates the behavior of the person in recovering balance after being pulled back, was considered as a dependent variable for postural stability. Likewise, joint stiffness was considered from the summation of the points in the sub-items (cervical, upper and lower limbs) of item 22 of the UPDRS. The motor condition was determined as the score obtained in the motor subscale of the UPDRS. The Hoehn & Yahr scale (H & Y) [24,27] was used to evaluate the staging of the disease.

In the functional reach test, the subject was asked to raise the arms to shoulder height and then perform maximum forward range without moving the feet. The maximum distance reached to the front was measured with a tape measure and expressed in centimeters (cm). The test demonstrates good reproducibility (ICC=0.836)[28] and good inter-rater reliability (ICC=0.81)[29]. Three attempts were performed and only the highest value was considered[30]. The functional reach test was performed on a force platform (Kistler, model 9286A) and the anteroposterior displacement (AP) of the center of pressure was calculated in the same trial, selected by the maximum distance reached to the front, obtained by means of a algorithm written in Matlab.

Participant performance in the functional reach test (maximum distance reached to the front and anteroposterior displacement of the center of pressure) was analyzed by means of descriptive statistics. The Spearman correlation test (rho) was used to verify the relationship between performance in the functional reach test and variables related to range of joint motion, postural stability, joint stiffness, motor condition, and staging of the disease.

Results

The demographic and anthropometric data characterizing the sample are presented in Table 1.

Table 2 presents the means and standard deviations of the variables related to postural stability, muscle rigidity, disease staging, motor condition, joint range of motion, and functional range.

Table 3 presents the results of the Spearman correlation (rho) between the functional range variables (maximum distance reached to the front and anteroposterior displacement of the center of pressure) and the demographic, anthropometric, range of joint movement, postural stability, joint stiffness, motor condition and staging of the disease variables. There was a positive ordinal correlation of moderate magnitude between the maximum distance reached to the front and the range of joint motion in ankle plantar flexion; while a negative ordinal correlation of moderate magnitude was observed between anteroposterior center of pressure displacement and postural stability.

Table 1. Characterization of the sample.

Variables	Mean ± standard deviation (range)
Gender (M/W)	11/14
Age (years)	69.9±6.94 (44-87)
Weight (Kg)	66.3±19.87 (43-103.6)
Height (cm)	152.5±32.74 (146-179)

Source: Authors.

Table 2. Mean and standard deviations of variables related to postural stability, muscle stiffness, disease staging, motor condition, joint range of motion, and functional range.

Variables	Mean ± standard deviation (range)
Postural Stability / Retropulsion (points)	0.8±0.58 (0-2)
Muscular Stiffness (points)	2.4±1.68 (0-5)
Disease Staging / H & Y (stage)	1.36±0.22 (1-1.5)
Motor Condition / Motor UPDRS (points)	18.68±7.45 (8-41)
Range of Articular Motion	
Trunk Flexion(°)	24.40±8.43 (10-42)
Hip Flexion(°)	83.86±11.92 (53.5-104)
Hip Hyperextension(°)	5.86±2.65 (1.5-11)
Knee Flexion(°)	110.48±15.21 (77.5-135.5)
Knee Hyperextension(°)	2.72±1.18 (0-5.5)
Ankle Plantar flexion(°)	32.46±7.04 (16.5-44)
Ankle Dorsiflexion(°)	21.14±8.02 (6-36)
Functional Reach	
Maximum distance to front (cm)	25.38±3.85 (18.17-34)
Anteroposterior displacement of center of pressure (cm)	2.69±0.70 (1.55-3.9)

Source: Authors

Discussion

The aim of the present study was to analyze performance in the functional reach test and its relation with associated factors, such as range of joint motion, postural stability, joint stiffness, motor condition, and staging of the disease. The results demonstrated that the ankle joint range of motion (plantar flexion) is associated with performance in the functional reach test, while postural stability is associated with the anteroposterior displacement of the center of pressure during the functional reach test.

Table 3. Spearman's correlation (rho) and significance (p-value) between the variables maximum distance reached to the front and anteroposterior displacement of the center of pressure with the demographic, anthropometric, range of joint motion, postural stability, joint stiffness, motor condition, and staging of the disease variables.

Variables	Maximum distance reached to the front	Anteroposterior displacement of center of pressure (AP)
Maximum distance reached to the front	-	rho=0.030; p=0.887
Anteroposterior displacement of pressure center	rho=0.030; p=0.887	-
Age	rho=0.366; p=0.072	rho=-0.163; p=0.436
Height	rho=0.119; p=0.581	rho=-0.070; p=0.745
Weight	rho=0.256; p=0.227	rho=-0.084; p=0.695
Postural Stability	rho=0.296; p=0.151	rho=**-0.417; p=0.038**
Muscular Stiffness	rho=-0.191; p=0.361	rho=-0.231; p=0.267
Disease Staging/H&Y	rho=0.186; p=0.373	rho=0.272; p=0.188
Motor Condition /motor UPDRS	rho=0.110; p=0.601	rho=0.191; p=0.361
Trunk Flexion	rho=-0.234; p=0.260	rho=0.138; p=0.510
Hip Flexion	rho=-0.150; p=0.474	rho=0.141; p=0.500
Hip Hyperextension	rho=-0.234; p=0.259	rho=0.249; p=0.230
Knee Flexion	rho=-0.210; p=0.315	rho=0.257; p=0.215
Knee Hyperextension	rho=-0.063; p=0.764	rho=0.191; p=0.360
Ankle Plantar flexion	rho=**0.450; p=0.024**	rho=0.230; p=0.268
Ankle Dorsiflexion	rho=0.181; p=0.385	rho=0.088; p=0.676

Source: Authors.

Individuals with instability, such as people with PD, typically use the hip and knee strategy in preference to the ankle strategy[31]. It is known that the ankle strategy is the first to be used when there is a disturbance[32]. Our results suggest that ankle joint range of motion plays an important role in the performance of a challenging task to postural stability. This is not a totally unexpected result, since the relationship between ankle joint range of motion and postural instability has already been demonstrated in individuals with joint instability[33] and even in healthy elderly individuals[34].

The aging process leads to a series of structural alterations, such as replacement of muscle fibers by connective tissue, an increase in the amount of collagen in periarticular structures, and reduction in the amount of synovial fluid[35]. As a final result of these limitations, there is a natural reduction in joint movement amplitudes. It is believed that this reduction, especially in the ankle, requires the use of other joints, such as the knee and hip[34]. This greater overload in joints other than the ankle can promote inadequate adaptations, causing greater imbalance[34]. Moreover, reduction in joint amplitude may overload other periarticular and muscular structures, which could eventually exacerbate overload in other joints[36]. This decrease in joint amplitude may have an even greater effect in people with PD, since they have articular stiffness underlying the disease[4].

The negative relationship between postural stability (measured by the retropulsion test) and the antero-posterior CoP displacement during the frontal reach test, is also not surprising. The functional reach test was developed with the intention of evaluating anteroposterior stability by measuring the maximum distance an individual manages to move their arm forward, while keeping their feet in contact with the ground[17]. Displacement of the center of mass to the front invariably promotes displacement of CoP in the same direction. Thus, greater performance in the functional reach test also promotes greater displacement of

CoP in the anterior sense. Therefore, since the functional reach test evaluates the anteroposterior stability of an individual, it is expected that the less the ability to move ahead, the worse the balance[30]. The retropulsion test is the "gold standard" test to evaluate postural stability and a key component in the clinical evaluation of people with PD[37]. Therefore, since both tests essentially evaluate the same phenomenon (postural instability), it is not surprising that the performances of both maintain a certain relationship.

However, the study by Behrman et al.[20] has already demonstrated that the functional reach test is not able to identify individuals with PD at a high risk for falls, different from those observed in healthy individuals[38]. Some factors that limit motor performance in patients with PD and that are not evaluated by the functional reach test have been identified as responsible for this difference. These factors include attentional deficits, sensory changes, lower strength levels, and reduced joint range of motion[20]. In fact, our results confirm that ankle joint amplitude is associated with performance in the functional reach test in patients with PD. Thus, our results have prominent clinical relevance, demonstrating the importance of maintenance of ankle joint amplitude in individuals with PD for good performance in functional activities that challenge balance, such as the functional reach test.

Some limitations of this study should be mentioned, such as the low number of individuals evaluated and the use of equipment with lower levels of precision than high frequency cameras or electrogoniometers. However, the results found were clear in demonstrating the influence of joint range of motion on performance in the functional reach test. In addition, the materials/methods used in this study are easy to apply and a reality in clinical practice, justifying their use.

Conclusion

It can be concluded that performance in the functional reach test in people with PD is determined by the individual level of balance and, above all, by the joint amplitude of the ankle. Thus, we believe that joint stiffness, the classic motor symptom of PD, associated with functional alterations of aging are the main factors responsible for worse performance in the functional reach test. Our results, therefore, reinforce the need to include flexibility exercises as a rehabilitation strategy in people with PD.

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