

Effects of physical exercise on articular range of motion of the lower limb in the Parkinson's disease individuals

Efeito do exercício físico na amplitude de movimento articular dos membros inferiores de indivíduos com doença de Parkinson

Efecto del ejercicio físico en la amplitud del movimiento articular de las extremidades inferiores de individuos con la enfermedad de Parkinson

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ABSTRACT | The aim of this study was to investigate the effect of eight months of a multimodal program of physical exercise on articular range of motion of the lower limb of patients with Parkinson disease (PD), considering gender and disease stage. Seventeen individuals with PD participated in this study. Participants were assessed before of multimodal program of the physical exercise and after four and eight months of physical exercise. In these periods were evaluated the clinical aspects and articular range of motion of the lower limb. For statistical analysis, patients were distributed according to gender and disease stage. A MANOVA considering exercise, gender and stage of disease, with repeated measures for the first factor, was performed. The clinical results showed regression of disease progression, indicating cognitive decline for women. The articular range of motion improved after four and eight months of physical exercise, especially for the hip and ankle, independent of gender and stage of PD. It was concluded that the multimodal exercise program of the eight months was effective in improving articular range of motion in patients with PD. The benefits of exercise for this physical capacity were independent of gender and severity of PD.

Keywords | Parkinson Disease; Exercise; Range of Motion, Articular.

RESUMO | O objetivo deste estudo foi verificar o efeito de oito meses de um programa multimodal de exercício físico na amplitude de movimento articular do membro inferior de pacientes com doença de Parkinson (DP), considerando gênero e estágio da doença. Participaram deste estudo 17 indivíduos com DP idiopática. Os participantes foram avaliados antes do período da execução do programa multimodal de exercício físico e após quatro e oito meses de exercício físico. Foram avaliados aspectos clínicos e a amplitude de movimento das articulações do membro inferior. Para análise estatística, os pacientes foram agrupados de acordo com gênero e estágio da doença, sendo realizada uma MANOVA com fator para exercício físico, gênero e estágio da doença, com medidas repetidas para o primeiro fator. Os resultados clínicos indicaram regressão da progressão da DP, com declínio cognitivo para as mulheres. A amplitude de movimento articular melhorou após quatro e oito meses de exercício físico, principalmente para o quadril e tornozelo, independente de gênero e estágio da doença de Parkinson. Conclui-se que o programa multimodal de exercício físico de oito meses foi eficiente em melhorar a amplitude de movimento articular de pacientes com DP, sendo os benefícios independentes do gênero e da severidade da DP.

Descritores | Doença de Parkinson; Exercício; Amplitude de Movimento Articular.

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RESUMEN | El objetivo de este estudio fue verificar el efecto de ocho meses de un programa multimodal de ejercicio físico en la amplitud de movimiento articular de la extremidad inferior de pacientes con enfermedad de Parkinson (EP), considerando género y la etapa de la enfermedad. El estudio incluyó a 17 sujetos con EP idiopática. Los participantes fueron evaluados antes del período de ejecución del programa multimodal de ejercicio físico y tras cuatro y ocho meses de ejercicio físico. Se evaluaron aspectos clínicos y la amplitud de movimiento de las articulaciones de las extremidades inferiores. Para el análisis estadístico, los pacientes fueron agrupados de acuerdo con el género y etapa de la enfermedad, mediante la realización de un MANOVA con factor

para ejercicio físico, género y estadio de la enfermedad, con medidas repetidas para el primer factor. Los resultados clínicos mostraron regresión de la progresión de la EP, y el deterioro cognitivo en las mujeres. La amplitud de movimiento articular mejoró tras cuatro y ocho meses de ejercicio físico, especialmente para la cadera y el tobillo, independientemente de su género y etapa de la enfermedad de Parkinson. Se concluyó que el programa multimodal de ejercicio físico de los ocho meses fue eficaz en mejorar la amplitud de movimiento articular en pacientes con EP, y los beneficios independiente del género y la gravedad de la EP.

Palabras clave | Enfermedad de Parkinson; Ejercicio; Rango del Movimiento Articular.

INTRODUCTION

The Parkinson disease (PD) is characterized by an imbalance in the circuits in charge of controlling the movements, due to the progressive loss of dopaminergic neurons¹. It is currently considered the second most common neurodegenerative disease worldwide, affecting approximately 1% of the world population over 65 years of age². The socioeconomic impact of PD on health services is high³, being needed interventions which assist in the treatment of PD. The drug intervention is still the main form of PD treatment⁴. However, recent researches indicate the effectiveness of exercise in the control of compromise and progression of the PD⁵⁻⁸. However, it is difficult to establish the components which should be included in an exercise program for this population^{7,8}. Moreover, aspects such as gender and severity of the PD may be important for the prescription of physical activity.

Studies of short and long duration have shown benefits of exercise in PD functional capacity⁸⁻¹¹, locomotion^{5,6}, postural control^{12,13} and cognitive functions^{14,15}. However, little is known about the effects of exercise on the articular range of motion in patients with PD. The literature has shown changes in the range of motion of the hip and knee articulations, due to the aging process¹⁶. For the PD, the joint range of motion is directly related to the motor symptoms, characteristics of the disease's engines, especially muscle rigidity and bradykinesia¹⁷. Schenkman and colleagues¹⁸ observed negative changes in articular range of motion of the spine and shoulders in patients with PD. So far, studies examining the effect of physical exercise on the articular range of motion in patients with PD, especially considering gender and stage of disease, have not been found in literature.

Thus, the objective of this study was to investigate the effects of eight months of a multimodal exercise program on articular range of motion of the lower limbs of patients with PD, considering gender and stage of the disease. The study hypothesis is that after eight months of exercises it would occur an improvement in the articular range of motion of the lower limbs. Specifically to the gender matter, it is expected that the benefits are similar for men and women, due to higher benefits that men presented for functional capacity¹¹ and the higher bioavailability of levodopa presented by women¹⁹. As for severity of the PD, it is expected that patients in more advanced stages have more benefits out of the exercise, due to the higher stiffness symptoms presented by this group²⁰.

METHODOLOGY

Seventeen subjects (age: 69.94 ± 7.39 years of age, height: 1.61 ± 0.09 m, body mass: 65.41 ± 9.96 kg) with idiopathic PD participated in this study. Patients were selected from the Physical Activity Program for Patients with Parkinson's Disease (PROPARKI-UNESP, Rio Claro). The inclusion criteria for sample selection were:

- to present a clinical diagnosis for idiopathic PD;
- to make regular use of medications to control the PD;
- to be between stages 1 and 3 on the Hoehn and Yahr (HY)²¹;
- not to participate in any other exercise program;
- not to have other neurological diseases associated with PD.

Patients were clinically evaluated by a neuropsychiatrist after agreeing to participate in the study and

signed an Informed Consent approved by the local Ethics Committee (No. 4960/2006). Participants were clinically evaluated by the neuropsychiatrist of PROPARKI. The tests used for these ratings were: the Unified Parkinson's Disease Rating Scale (UPDRS)²², which evaluates the impairment of the disease, being divided into three subscales: psychological, functional and motor; The HY, which establishes the stage of the disease; and the Mini Mental State Examination (MMSE)²³, which establishes the cognitive impairment of patients.

The range of motion was assessed using a goniometer (universal goniometer by Carci®) in the following joints of the right lower limb: hip (internal and external rotation, adduction and abduction), knee (flexion and extension) and ankle (plantar flexion and dorsiflexion). The procedures for the registration of the articular range of motion followed the indications of Palmer and Epler²⁴. All reviews were performed one hour after the ingestion of the drug ("ON" state of the medication).

Clinical and range of motion of the joints of the lower limb assessments were performed (Figure 1): before the period of implementation of the multimodal exercise program (pretest); after four months of physical exercise (post-test I); and after eight months of physical exercise (post-test II). The multimodal exercise program was characterized by

widespread physical activity with the aim of training the components of functional capacity (aerobic endurance, flexibility, strength, motor coordination and balance). In general, the activities were classified as rhythmic, located gymnastics, recreational activities, stretching, activities for the components of physical fitness and activities for cognitive functions. The exercise program was divided into 2 periods of 4 months (totaling 8 months), with a break of 15 days between periods, for the review. Each period presented 3 phases with 4 cycles of 16 sessions, totaling 48 sessions in each period (96 sessions in total). The frequency of exercise was 3 times per week, each session lasting 60 minutes.

The exercise sessions were organized into four parts: warm up and stretching, main part (where one of the components of functional capacity was emphasized), secondary part (in which two of the components of the associated functional capacity were worked) and back to calm state and final stretching. The progression the physical exercise occurred in the intensity and complexity of the activities, according to each component of functional capacity:

- Aerobic endurance: the specific activities for this component maintained the patient's heart rate between 60 and 75% of their maximum heart rate, controlled by a frequency meter counter (Polar FC RS 200SD® – Kemple, Finland).

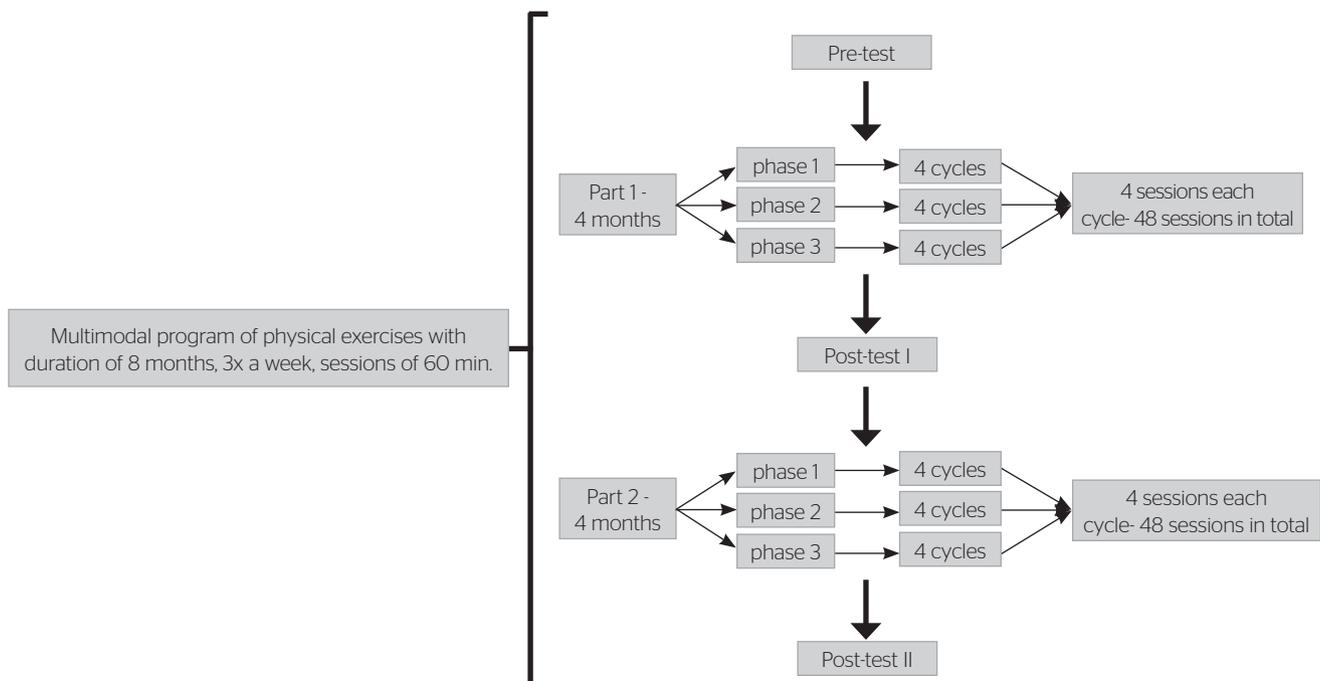


Figure 1. Outline of the multimodal exercise program and evaluation periods

The progression occurred every two cycles, with an increase in the number of series and a decreased in the recovery time, and, at each phase, with increased intensity and complexity of the environment;

- Flexibility: the articulation worked varied in each cycle. During the activities, passive and active stretchings were used. The progression of the exercise occurred at each phase, with an increase in the number/uptime of the activities and in series with the use of complementary materials, such as ropes and elastic bands with different densities and resistance strengths;
- Muscular strength: the exercises trained upper and lower limbs and trunk. Resistance exercises using free materials and special machines for the resistance training, especially for the large muscle groups of each body region, were used. The progression occurred every two cycles, with an increase in the number of sets and/or repetitions, and at each phase, an increase in the load;
- Motor coordination: the exercises have involved visual motor skills and coordinative activities for upper and lower limbs. The progression occurred in each cycle, with the change of the material used, and at each phase, with an increase in the complexity of the task;
- Balance: exercises involving static and dynamic balance. The progression occurred every two cycles, with increasing complexity, and at each phase, with a disturbance of the somatosensory, vestibular and visual systems.

To answer the questions of the study, patients were grouped according to gender (women, $n=7$, and men, $n=10$) and disease stage (initial HY stage between 1 and 1.5, $n=9$ and moderate HY stage above 2, $n=8$). The effect of the physical exercise on the articulation range of motion, in general and according to gender and stage of the disease, was verified by the use of a MANOVA ($p=0.05$) with an exercise factor (pretest, post-test I, post-test II), gender (women and men) and stage of the disease (early and moderate), with repeated measures for the first factor. When the MANOVA showed effect, the Bonferroni post hoc test was used, in order to indicate the differences. The effect of physical exercise on the clinical variables (UPDRS and MMSE) was analyzed in the same way. It is important to note that all patients included in the analysis have participated in more than 70% of the sessions.

RESULTS

For the clinical variables (Table 1), the MANOVA indicated the interaction between physical exercise and gender (Wilks' $\lambda=0.45$, $F_{2,12}=1.71$, $p<0.05$), indicating no effect of the physical exercise (Wilks' $\lambda=0.11$, $F_{2,12}=1.25$, $p=0.52$) and interaction between physical exercise and the disease stage (Wilks' $\lambda=0.16$, $F_{2,12}=0.85$, $p=0.65$). For the interaction between physical exercise and gender, the post hoc test indicated that women had a worsening after four months of physical exercise on the MMSE and maintenance of the cognitive performance after eight months of physical exercises ($p<0.02$).

For the articular range of motion (Figure 2), the MANOVA indicated effect of the physical exercises (Wilks' $\lambda=0.19$, $F_{20,34}=2.16$, $p<0.02$), without indicating interaction between physical exercise and gender (Wilks' $\lambda=0.47$, $F_{20,34}=0.78$, $p=0.71$) and between physical exercises and the disease stage (Wilks' $\lambda=0.56$, $F_{20,34}=0.56$, $p=0.91$). The post hoc tests indicated that the physical exercise improved the range of motion for the abduction and adduction of the hip and ankle dorsiflexion. The range of motion of hip abduction showed an increase after eight months of physical exercises ($p<0.05$). The range of motion of the hip adduction showed an increase after the first four months of physical exercises, but without maintenance of this increase after eight months of physical exercises ($p<0.05$), returning to the pre-test level. The range of motion of ankle dorsiflexion showed an increase after four months of physical exercises, maintaining the values after eight months ($p<0.04$).

DISCUSSION

The aim of this study was to investigate the effects of eight months of a multimodal physical exercise program on the articular range of motion of lower limbs of patients with PD, considering gender and the stage of the disease. In general, the results confirmed the hypothesis of the study, indicating that after eight months of physical exercises there is an improvement in the articular range of motion in patients with PD. This finding corroborates studies which verified the effect of long-term physical exercises^{6,8,11}, indicating that the physical exercise is important in controlling the progression of PD. However, the effect of physical

Table 1. Means and standard-deviations in the Unified Parkinson's Disease Rating Scale and in the Mini Mental State Exam variables for each evaluation

	Pre-test	Post-test I	Post-test II	Effect of the exercise
Psychological-UPDRS (pts)				
Woman	3.00±1.73	3.14±1.57	2.85±1.77	ns
Man	3.30±1.89	2.60±2.06	2.90±2.23	
Early stage	2.88±1.96	2.66±1.80	2.33±2.12	ns
Moderate stage	3.5±1.60	3.00±2.00	3.50±1.77	
Total	3.18±1.78	2.82±1.85	2.88±2.00	ns
Functional-UPDRS (pts)				
Woman	8.86±4.02	8.57±4.27	9.28±4.64	ns
Man	14.90±5.20	14.10±7.76	14.00±7.27	
Early stage	9.77±5.21	8.44±4.53	8.88±4.72	ns
Moderate stage	15.37±4.47	15.62±7.52	15.62±6.82	
Total	12.41±5.53	11.82±6.82	12.06±6.60	ns
Motor-UPDRS (pts)				
Woman	20.43±6.63	19.14±6.49	20.14±7.10	ns
Man	27.90±13.86	26.50±14.78	24.30±16.26	
Early stage	18.88±9.50	16.88±5.92	15.22±5.54	ns
Moderate stage	31.50±10.86	30.87±13.79	30.87±14.49	
Total	24.82±11.79	23.47±12.35	22.59±13.12	ns
Total-UPDRS (pts)				
Woman	32.29±11.25	31.00±10.73	32.28±12.22	ns
Man	45.10±17.72	43.20±21.65	41.20±22.80	
Early stage	30.44±12.52	28.11±10.86	26.44±10.02	ns
Moderate stage	50.37±13.76	49.50±19.42	50.00±19.82	
Total	39.82±16.32	38.18±18.58	37.53±19.21	ns
MMSE (pts)				
Woman	27.14±2.41	24.85±3.93	25.00±3.74	Woman: pre-test>post-test I and post-test II
Man	26.85±3.00	27.60±2.22	27.40±2.71	
Early stage	28.11±0.60	27.55±2.55	27.33±2.69	ns
Moderate stage	25.68±3.55	25.25±3.65	25.33±3.77	
Total	26.97±2.70	26.47±3.14	26.41±3.30	ns

UPDRS: Unified Parkinson's Disease Rating Scale; MMSE: Mini Mental State Examination

exercises on articular range of motion seems not to be influenced by gender and by the severity of the PD, indicating that the effects are independent from these aspects.

The multimodal physical exercise program appears to improve articular range of motion in patients with PD, especially for the abduction and adduction of the hip and ankle dorsiflexion. The improvement in the articular range of motion may be explained by the characteristics of generalized exercises prescribed for patients:

- emphasis on improving functional capacity, especially muscle strength¹¹, facilitating an increase in range of motion due to improved neuromuscular control;
- compensation of biochemical and physiological characteristic deficits of the PD²⁵, enhancing dopamine synthesis and its absorption.

Still, the improvement in the articular range of motion is directly related to better balance control and mobility²⁷. The increased range of motion of the hip joint is directly related to lower risk of falls, once elderly fallers with PD have less movement and acceleration of the hip during walking²⁸. The improvement in the articular range of motion of ankle dorsiflexion may lead to greater control of the movement, especially in gait in order to absorb the load during walking and in posture for balance control, benefiting patients in their mobility²⁹. Furthermore, the exercises were able to reverse the progression of the PD, which tends to increase in around 10% a year²⁶, as indicated by the maintenance of the clinical parameters and confirming previous studies⁶. With this, it may be suggested that the severity and progression of the proposed physical exercise program were appropriated in order to improve the articular range of motion and to control the progression of the PD.

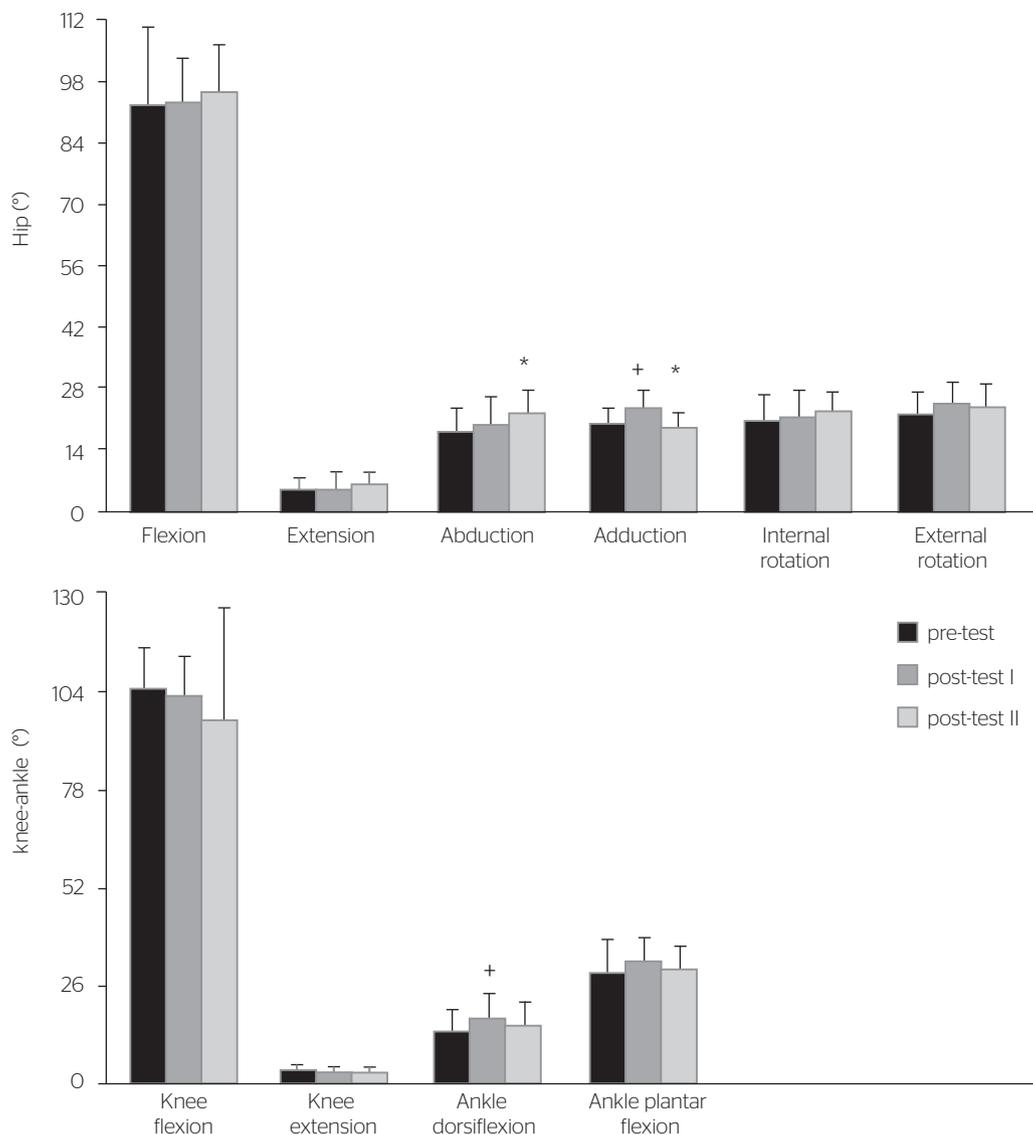


Figure 2. Means and standard-deviations in the articular range of movement of patients for eachs evaluation

The benefits of the physical exercise program on the articular range of motion were independent of gender and PD severity. The widespread nature of the exercise seems to benefit men and women similarly, and patients in both early and moderate stages of PD. This result contradicts the findings in the literature¹¹ which indicate that the benefits of physical exercise occur according to gender and the severity of the PD. One possible explanation for the independence of the benefits in relation to gender and the severity of the PD is the relationship between articular range movement and the signs/symptoms of the PD, especially muscle rigidity and hypokinesia¹⁹, since all the PD patients exhibit these motor symptoms in some degree. Thus, the range of motion of the patient

with PD will benefit from the exercise, regardless of gender and stage of the PD, preserving or restoring joint movement and reaching, consequently, much of the movement needs of patients with PD.

CONCLUSION

It may be concluded that the multimodal exercise program of eight months was effective in improving the articular range of motion in patients with PD. The benefits of physical exercise for that physical capacity, were independent of gender and of PD severity.

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