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Muscle strength, functionality and quality of life in patients with Parkinson's disease after low volume resistance training: a randomized clinical trial

Força muscular, funcionalidade e qualidade de vida em pacientes com doença de Parkinson após treinamento resistido de baixo volume: um ensaio clínico randomizado

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ABSTRACT

Introduction: Resistance Training (RT) or strength training increases muscle strength and reduces motor symptoms in Parkinson's Disease (PD). **Objective:** To investigate the effects of low volume RT on muscle strength, functional performance, and quality of life in patients with mild to moderate Parkinson's disease. **Material and Methods:** A randomized clinical trial was conducted with 15 PD patients, aged 64.27 ± 7 years, divided into Control Group (CG), n= 6, and Resistance Training Group (RTG), n= 9. CG did not engage in exercise. RTG underwent individualized RT for 8 weeks, consisting of 6 exercises, 2 sets of 10 repetitions with a load of 60% to 80% of 10 RM (maximum repetitions), and a 2-minute rest interval. The assessments included 10 RM muscle strength tests for bench press and leg press, functional performance using the Time Up and Go (TUG) test, and quality of life assessed with the Parkinson's Disease Questionnaire-39 (PDQ-39). Data analysis employed Chi-square, Student's t-test, paired t-test, and Wilcoxon test using the Statistical Package of Social Sciences (SPSS, 23.0) with a significance level of $p<0.05$. **Results:** The groups were similar before the intervention. After 8 weeks, there was a significant difference between CG and RTG, respectively: in bench press muscle strength: (25.83±8.61 kg) (43.33±15.6 kg), p= 0.03; leg press: (40.83±25.58 kg) (97.22±16.22 kg), $p<0.001$; TUG: (12.70±3.42 seconds) (6.94±1.01 seconds), $p<0.001$; and PDQ-39 score: (41.88±16.70) (18.09±6.78), p= 0.02. After 8 weeks, CG experienced a significant decline ($p>0.05$) in quality of life. However, RTG showed a significant increase ($p>0.05$) in muscle strength, functionality, and quality of life. **Conclusion:** Low volume RT increased the muscle strength of upper and lower limbs, improved functional performance, and enhanced the quality of life of patients with mild to moderate Parkinson's disease.

Keywords: Parkinson's Disease; Exercise; Muscle Strength.

RESUMO

Introdução: O treinamento resistido (TR) ou musculação aumenta a força muscular e reduz sintomas motores na doença de Parkinson (DP). **Objetivo:** Verificar os efeitos do TR de baixo volume na força muscular, performance funcional e qualidade de vida de pacientes com DP leve a moderado. **Material e Métodos:** Um ensaio clínico randomizado foi realizado com 15 pacientes com DP de 64,27 ± 7 anos, divididos em: Grupo Controle (GC), n= 6, e Grupo Treinamento Resistido (GTR), n= 9. O GC não realizou exercício. O GTR realizou o TR individualizado, por 8 semanas. Cada treino com 6 exercícios, 2 séries de 10 repetições com carga de 60% a 80% de 10 repetições máximas (RM) e intervalo de descanso de 2 minutos. As avaliações foram: teste de força muscular de 10 RM no supino e *leg press*; performance funcional no *Time Up and Go* (TUG) e qualidade de vida pelo *Parkinson's Disease Questionnaire*-39 (PDQ-39). Na análise dos dados foram utilizados o Qui-quadrado e t de *Student*, além do t pareado e Wilcoxon com o *Statistical Packageof Social Sciences* (SPSS, 23.0) e significância de $p<0,05$. **Resultados:** Os grupos estavam similares antes da intervenção. Após 8 semanas houve diferença significativa entre GC e GRT, respectivamente: na força muscular no supino (25,83±8,61 kg) (43,33±15,6 kg), p= 0,03; no *leg press* (40,83±25,58 kg) (97,22±16,22 kg), $p<0,001$; no TUG (12,70±3,42 segundos) (6,94±1,01 segundos), $p<0,001$; e no *score* do QDP-39: (41,88±16,70) (18,09±6,78), p= 0,02. Após 8 semanas, no GC houve piora significativa ($p>0,05$) da qualidade de vida. No entanto, no GTR houve aumento significativo ($p>0,05$) da força muscular, da funcionalidade e da qualidade de vida. **Conclusão:** O TR de baixo volume aumentou a força muscular de membros superiores e inferiores, além de melhorar a performance funcional e a qualidade de vida de pacientes com DP leve a moderado.

Palavras-chave: Doença de Parkinson; Exercício Físico; Força Muscular.

INTRODUCTION

Parkinson's Disease (PD) is a progressive neurodegenerative disorder that affects the central nervous system and is characterized by dysfunction of the dopaminergic system, which leads to impaired motor function and affects millions of people worldwide.[1] The prevalence of PD increases with population aging and is higher in the male sex.[1]

The main motor symptoms of PD are tremors, stiffness, bradykinesia, and postural and gait instability, hindering functionality and quality of life.[2] Besides, PD also displays non-motor symptoms, such as smell alterations, sleep and urinary disorders, depression and mood changes.[2] PD can be treated with pharmacological therapy (dopamine replacement) and/or surgery.[2] However, drug and surgical treatment combined with non-pharmacological treatment, which includes physical exercise, increase the positive responses in the control of PD symptoms.[3] Regular physical exercise, whether aerobic and/or resistance training, can help restore and expand motor functions, as well as reduce and delay the progression of motor and non-motor symptoms.[1,3,4,5]

Resistance training (RT), also known as weight training, is an effective type of exercise to promote hypertrophy and increase muscle strength in elderly people with PD.[6,7] Systematic reviews with meta-analysis have shown the benefits of resistance training in increasing upper and lower limb muscle strength, balance, gait stability and, consequently, the overall functionality after a few weeks of RT in adults and elderly people with PD.[3,8,9] Furthermore, progressive RT has increased the muscle strength of lower limbs, the functional and gait performance of PD patients undergoing rehabilitation.[10] The increase of muscle strength in PD is associated with the improved capability of performing daily tasks (getting dressed, climbing stairs, sitting down and standing up) with greater autonomy and reduced fall risk.[11,12, 13]

Recent meta-analyses concluded that progressive RT increased muscular strength and reduced motor symptoms and depression, and increased the quality of life for PD patients.[1,3] Moraes Filho et al[14] showed that after a nine-week resistance training (RT) program there was a decrease in bradykinesia, along with increased strength and functionality in PD patients. Studies suggest that muscle weakness can affect people with PD and influence the progression of the disease's motor symptoms.[15,16]

In spite of RT benefits to PD patients, there are insufficient clinical practice guidelines for performing RT in PD individuals.[3] Furthermore, evidence for the benefits presented here comes from a wide variety of RT protocols in studies.[3] However, it remains unclear whether low-volume protocols (less sets, exercises, and training time) are equally effective in increasing muscle strength and functionality in PD when compared to high-volume RT. In addition, the exclusive effects of RT as the only intervention have been little investigated and most clinical trials have evaluated RT associated with other types of exercise (aerobic, functional, and balance training).[17,18] As the aim of this clinical trial was to verify the effects of low-volume RT on muscle strength, functional performance, and quality of life in patients with mild to moderate PD, the isolated effects of low-volume RT were evaluated in this study.

MATERIAL AND METHODS

Study type and location

This is a randomized clinical trial carried out at a University Hospital in Brazil. The study protocol was approved by the Human Research Ethics Committee (CAAE: 15553819.0.0000.5078).

Participants

Fifteen elderly Parkinson's disease patients with a mean age of 64.27±7.17 years took part in the study. After screening patients diagnosed with PD, the neurologists referred 15 patients to the Physical Education clinic who were suitable for regular exercise. The recruiting, as referred by the physicians, took around 3 months to be done. In order to classify the stage of PD severity, the neurologists used the Hoehn and Yahr Scale (HY). The Hoehn and Yahr Scale is used to estimate the symptom severity, ranging from one (small disease indications, unilaterally) to five (severe disability, wheelchair user).[19] The participants were classified from mild to moderate severity according to the Hoehn and Yahr Scale, of which five (33%) patients were at stage 1, five (33%) at stage 2 and five (33%) at stage 3. The time of PD progression was not recorded for this sample. Additionally, all patients were taking some of the following medications: levodopa/carbidopa, dopamine agonist and amantadine.

The number of 15 PD patients was determined as a convenience sample. The patients were randomized into 2 groups: experimental and control. The experimental Resistance Training Group (RTG) had 9 patients, and the Control Group (CG) had 6 patients. The study design is shown in Figure 1.

The two groups were randomized using a computer-generated drawing of lots method. Patients were blindly designated to each group by an investigator who was not involved in participant recruitment and training. The allocation of the participants was concealed into sealed, opaque envelopes. On the first day of intervention, the envelope assigned to each participant was opened by the Physical Education professional who provided the intervention.

The groups were evaluated before (PRE) and

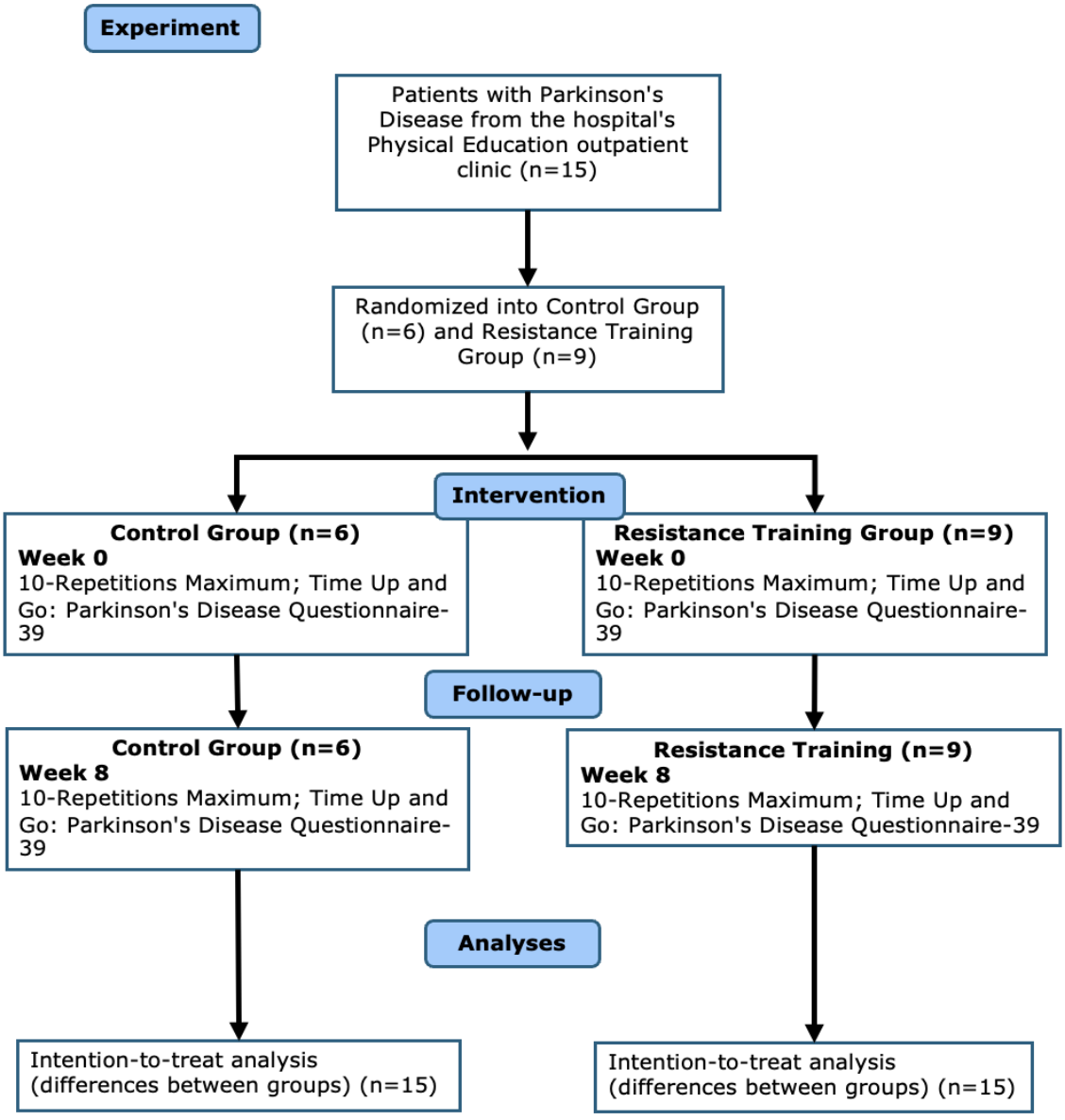

Figure 1: Study design.

after (POST) eight weeks of intervention with RT (RTG) and non-exercise control (CG). Assessments of muscle strength, functionality and quality of life were carried out in PRE and POST moments. A blind evaluation during data collection was performed by professionals of the hospital's Physical Education clinic. Data analysis was also blind, that is, carried out by a third-party statistician who was not a member of the research team. In this study, muscle strength is the primary outcome, whereas functional performance and quality of life are secondary outcomes.

Inclusion and exclusion criteria

The inclusion criteria included a confirmed diagnosis of Parkinson's disease, adherence to regular treatment for the condition, and absence of participation in any form of systematized physical activity. The exclusion criteria required that participants must not have decompensated diabetes mellitus, decompensated congestive heart failure, a recent cardiovascular event (within the past three months), chronic kidney failure, a clinical diagnosis of dementia or psychiatric disorders, or any physical or mental limitation that could hinder their ability to perform the exercises or understand the questions. Furthermore, participants who attended less than 80% of the resistance training sessions in the RTG were excluded.

Intervention and assessment

The patients attended the first visit to the hospital's Physical Education clinic for a presentation and detailed explanations about the research. The 15 patients agreed to take part in the study and signed the Free and Informed Consent Form (FICF), making them ready to carry out the study procedures. During the first visit, a clinical assessment was carried out, which consisted of applying the Quality of Life Questionnaire for PD, validated in Brazil in 2005 and adapted into Brazilian Portuguese at the Health Services Research Unit.[20] The Parkinson's Disease Questionnaire-39 (PDQ-39) is a quality of life measure consisting of 39 separate items, each answered in a Likert-like scale of five points (never, occasionally, sometimes, often, always). The questionnaire addresses eight domains: mobility, activities of daily living (ADL), emotional well-being, stigma, social support, cognition, communication and bodily discomfort; and a summary index score. The PDQ-39 was also conducted after eight weeks of intervention.

At the first visit to the hospital outpatient clinic and after the eight-week intervention, the Time Up and Go (TUG) Test was conducted, which is a widely used clinical assessment to measure fall risk and functional mobility and balance.[21] The test starts with participants sitting on a chair with their hands in their lap. Upon verbal prompting, the subject stands up (without using their hands), walks around a cone placed on the floor three meters from the front edge of the chair, and returns to the starting position on the chair. Participants were encouraged to walk around the cone in the same direction and complete the task as quickly as possible.[21]

At the second visit to the hospital's outpatient clinic and after eight weeks of intervention, the 10-repetition maximum (RM) test was carried out to measure muscle strength in the bench press (upper limb) and leg press (lower limb). It was used for adaptation and gestural learning and as a maximum load test.[22] The 10-RM test protocol followed the guidelines for executing the exercises, as it has been previously documented.[13] Before the 10-RM test, two light sets of warm-up exercises consisting of 15 repetitions were performed so that the participants could get used to the movement technique in the bench press and in the leg press. Subsequently, patients had two more attempts to reach the 10-RM load, with an interval of 3-5 minutes between attempts and exercises. Before the test began, participants were kept at rest while receiving guidance from instructors, and verbal encouragement was provided during all 10-RM attempts.[22] The 10-RM training load was determined based on the familiarization session with all the exercises in the RT program.

The RTG program was individualized and monitored by an experienced Physical Education professional and carried out at the hospital's Physical Education outpatient clinic twice a week for 8 weeks. The RT program was low volume, and it consisted of 6 exercises: free squats evolving to squats with dumbbells, front lat pulldown, leg press, and barbell bench press, divided into 2 sets of a maximum of 10 repetitions, with an intensity of 60% to 80% of 10-RM. Lumbar hyperextension in prone position was performed in 2 sets of 10 repetitions and front plank for 1 minute of isometric hold. All exercises had 2-minute rest intervals between sets. The Valsalva maneuver was discouraged for all participants and breathing was controlled. In every RTG session, blood pressure was measured before and after the session with patients remaining at rest and seated for 10 minutes.[23]

The CG did not engage in any physical exercise for eight weeks. However, in order to ensure the ethical aspects and training benefits after eight weeks of control, the patients in this group were invited to perform the RT protocol.

The patients' food intake was not controlled, but they were asked to avoid altering their calorie intake during the study. The purpose of this procedure was to try to ensure that the dietary intake would not be a confounding factor in the intervention results.

Statistical analysis

Data were analyzed using the Statistical Package for Social Sciences (SPSS, version 23.0). The normality of the data was verified using the Shapiro-Wilk test. The CG and RTG demographic and anthropometric profiles as well as their variables were characterized using contingency tables and Chi-square and Student's t-tests to identify differences between the groups. Comparisons of all the CG and the RTG variables were performed before and after intervention using paired t-tests and the Wilcoxon test. A significance level of 5% ($p < 0.05$) was adopted for all analyses.

RESULTS

The profile information and the initial characterization of the PD patients are shown in Table 1. Most of the patients were elderly males. There was no sample loss. The 15 PD patients started and completed the study in their respective groups. All the RTG patients carried out the 16 sessions during the eight weeks, and there were no adverse events in either group.

Table 1 shows that CG and RTG were similar before the intervention, since there was no significant difference between both groups in the PRE moment in none of the variables. The similarities between groups in the PRE-intervention moment can also be seen in Table 2, in which only one variable from the PDQ-39 (cognition) presented a significant difference.

In Table 2, the comparison between groups after intervention (POST) demonstrated that upper

limb muscle strength (10-RM) increased significantly by 17.5 kg in the RTG, whereas lower limb strength (10-RM) had a significant increase of 56.39 kg. Functional mobility or functionality assessed in the TUG improved with a significant decrease in test time of 5.76 seconds in the RTG. In the PDQ-39 Quality of Life Questionnaire there was also a significant improvement in the RTG when compared to the CG in the scores of the following domains: mobility by 34.31; activities of daily living (ADL) by 23.14; stigma by 20.83; cognition by 24.65; communication by 40.74; and in the total PDQ-39 score by 23.79.

Table 2 shows the comparison between the PRE and POST-intervention moments for each group. After the intervention, there was a significant worsening in the CG scores of the following domains: emotional well-being by 8.33; stigma by 8.33; and total score by 5.13. In the RTG, there was muscle strength improvement of upper limbs by 16.77kg, of lower limbs by 55.89 and TUG reduction of 4.57 seconds after intervention. Moreover, there was a significant quality of life improvement after intervention (PDQ-39) in the scores of the following domains: activities of daily living by 23.14; well-being by 24.53; social support by 31.48; and communication by 34.26.

DISCUSSION

The aim of this study was to verify the effects of a resistance training program on muscle strength, functionality and quality of life of PD patients. The main findings of our research demonstrated that after intervention there was a significant increase in muscle strength of lower and upper limbs and in functional performance as assessed by the TUG test, when comparing the RTG and the CG. In addition, the RTG showed an improvement in quality of life with significantly increased scores in the domains of mobility, activities of daily living, stigma, cognition, communication and total score of the PDQ-39 after intervention. Moreover, among the RTG patients, a significant improvement in the strength, TUG and quality of life tests was observed in the domains of activities of daily living, emotional well-being, social support and communication after 8 weeks. However, the CG showed a significant worsening of quality of life in the domains of stigma, communication and emotional well-being.

Corroborating our findings, two systematic reviews with meta-analyses published in 2022 and 2023 found that the RTG increased muscle strength, motor symptoms and quality of life of PD patients.[1,3] Furthermore, the moderate-intensity progressive RT, done 2 to 3 times a week for 8 to 10 weeks, resulted in considerable gains in muscle strength, functional performance and motor symptoms enhancement, in

Table 1: Characterization of the patient's initial profile in each group.

Groups	**CG** (n= 6)	**RTG** (n= 9)	**Total** (n= 15)	***p***
Mean ± SD				
Age (years)	61.33±4.93	66.22±8.00	64.27±7.17	0.21*
Height (m)	1.63±0.12	1.67±0.10	1.65±0.10	0.56*
Weight (kg)	64.67±20.33	69.46±9.34	67.54±14.26	0.54*
BMI (Kg/m^2)	23.78±4.39	24.96±2.25	24.49±3.18	0.50*
N (%)				
Age group				
<60	1 (16.7%)	2 (22.2%)	3 (20.0%)	0.79**
60 to 80	5 (83.3%)	7 (77.8%)	12 (80.0%)	
Sex				
Female	2 (33.3%)	2 (22.2%)	4 (26.7%)	0.63**
Male	4 (66.7%)	7 (77.8%)	11 (73.3%)	
BMI (Kg/m^2)				
<25	5 (83.3%)	6 (66.7%)	11 (73.3%)	0.47**
≥25	1 (16.7%)	3 (33.3%)	4 (26.7%)	

*Student's t-test; **Pearson's Chi-square; Significance of p<0.05; SD: standard deviation; GC: Control Group; RTG: Resistance Training Group; BMI: body mass index.

Table 2: Continuous outcome results, 10-RM test, TUG and PDQ-39 questionnaire before (PRE) and after (POST) the intervention in the groups Control (CG) and Resistance Training (RTG).

	PRE			**POST**		
Groups	**CG**	**RTG**	***p***	**CG**	**RTG**	***p***
10-RM Upper Limbs (Kg)	25.83±8.61	26.56±8.11	0.87	25.83±8.61	43.33±15.61**	0.03*
10-RM Lower Limbs (Kg)	42.83±24.94	41.33±19.39	0.89	40.83±25.58	97.22±16.22**	<0.001*
TUG (s)	12.13±2.78	11.51±3.63	0.72	12.70±3.42	6.94±1.01**	<0.001*
PDQ-39						
Mobility	50.83±31.92	32.50±29.21	0.27	51.25±34.60	16.94±11.71	0.01*
ADL	38.19±9.65	45.83±20.30	0.41	45.83±18.45	22.69±19.33**	0.04*
Emotional well-being	34.72±12.54	50.92±24.72	0.16		26.39±24.91**	0.17
Social support	29.17±23.42	46.30±33.36	0.29	36.11±26.18	14.81±13.68**	0.06
Bodily discomfort	11.11±14.59	25.00±11.78	0.08	13.89±16.39	21.30±17.23	0.42
Stigma	22.92±20.41	18.75±16.24	0.66		10.42±11.69	0.03*
Cognition	37.50±16.30	15.97±15.02	0.02*	38.54±17.86	13.89±16.47	0.02*
Communication	41.67±21.08	46.30±34.13	0.77	52.78±23.96	12.04±16.20**	0.002*
Total PDQ-39 *Score*	36.75±12.32	35.83±16.01	0.90		18.09±6.78**	0.002*

The results are expressed as mean ± standard deviation. *Significance (p<0,05) between the groups; **Significance (p<0,05) between the PRE and POST moment in each group; RM= repetition maximum; TUG: *Timed Up and Go* test*;* PDQ-39*: Parkinson's Disease Questionnaire-39*; ADL: activities of daily living.

Furthermore, the moderate-intensity progressive RT, done 2 to 3 times a week for 8 to 10 weeks, resulted in considerable gains in muscle strength, functional performance and motor symptoms enhancement, in people with early to moderate PD.9 Another meta-analysis by Li et al[10] concluded that progressive RT improved lower-limb strength, gait performance, quality of life, and functionality (TUG) in PD patients undergoing rehabilitation. In contrast, a meta-analysis by Lima et al[24] found significant increases in muscle strength but did not report improvements in TUG functional performance following RT in PD patients.

In our study, there was a significant increase in muscle strength in the 10-RM leg press test after low-volume RT. Two clinical trials found increased muscle strength in the 1-RM test leg press test, but used high-volume RT protocols (higher number of exercises and sets).[25,26] It is worth noting that we have chosen the 10-RM test as it was considered to be the safest and most reliable test for this clinical population according to studies.[22,32] In addition, the RTG patients had a 10-repetition exercise protocol. They were therefore adapted to this number of repetitions in the leg press and bench press, which may have facilitated strength gains in the 10-RM test. This fact, together with the patients' initial muscle weakness, may explain the significant increase in muscle strength after 8 weeks of RT (Table 2).

In our results, there was a significant increase in muscle strength in the bench press (upper limbs) compared to the CG after 8 weeks of moderate intensity RT. This finding is in accordance with Cherup et al[27], with PD patients over 50 years old, after 12 weeks of RT. However, they did not find an increase in functional performance (TUG) and quality of life.[27]

Corroborating our findings, Moraes Filho et al[14] performed a RT protocol similar to ours for 9 weeks, twice a week, and found an increase in functional mobility (TUG) and isokinetic knee extension strength, in addition to a decrease in motor symptoms (bradykinesia) in elderly individuals with moderate PD and a mean age of 64 years. Helgerud et al[13] found a significant strength increase in the bench press and leg press, as well as an improvement in functional performance in the TUG and quality of life after high-intensity RT (>90% of 1 RM) for 4 weeks in elderly PD individuals.

Table 2 shows that the CG and the RTG (PRE moment) and the CG (POST moment) reached values close to the cut-off value for risk of falls in the Brazilian population (12.47 seconds).[28] After eight weeks, on the other hand, the RTG significantly decreased TUG time, displaying excellent functional mobility within normal

parameters and no risk of falling.[5,28] The average age (66 years) and mild to moderate PD in the study sample may have contributed to these results. We suggest that RT likely contributed to increased muscle strength, balance, and mobility, resulting in TUG values lower than normal values for the elderly (<11 seconds)[29] and for elderly PD with low risk of falls (11 to 20 seconds).[30]

Patients in our study had a significant increase in functional mobility (TUG) and quality of life after RT. Moreover, they presented low scores for quality of life in the PRE intervention moment, demonstrating severe impairment regarding physical, psychological and social aspects. However, the RT program was effective in significantly improving the total PDQ-39 score and the score for the following domains: mobility, activities of daily living, stigma, cognition, and communication. These results corroborate Ferreira et al[31] and Lima et al[5] who found a significant increase in functionality (TUG) and in the total PDQ-39 score. In addition, Demonceau et al[4] showed a significant improvement in the stigma and emotional well-being domains. These two studies investigated elderly PD patients assessed by the PDQ-39 after progressive RT compared to the CG.[4,5]

Clinical implications

Rehabilitation based on physical exercises in Parkinson's Disease (PD) can complement clinical and drug treatments, helping to delay the progression of motor symptoms such as bradykinesia, rigidity, freezing, reduced gait speed, and, consequently, falls and disability.[1,14] Furthermore, a regular physical exercise program, including solely resistance training (RT) or combined with aerobic and functional training, should be an adjunct to PD treatment, contributing to restore motor functions and addressing musculoskeletal disorders secondary to PD, such as muscle weakness and decreased aerobic capacity.[4,25] Despite the benefits of RT for people with PD, there is a lack of sufficient clinical guidance on how to implement resistance exercises for this population.[3]

Resistance training (RT) is an effective resource for increasing muscle strength and muscle mass.[7] These two parameters are essential for improving functional physical capacity, preventing sarcopenia and frailty, thus delaying disability in older adults.[7,31] In addition, regular and progressive RT enhances positive changes in functional parameters such as mobility, balance, gait speed, and reduced risk of falls in individuals with Parkinson's disease (PD).[3,14]

The increase in muscle strength and TUG performance are accompanied by improved functional capacity of the elderly with PD, leading to greater autonomy in daily activities such as sitting down and standing up, climbing stairs, and walking, among others.[11-13] The ability to perform functional tasks more dependent on the neuromuscular system is positively associated with lower limb strength in elderly individuals with PD.[10] Such tasks are the ones involving the upward displacement of body mass.

Moreover, enhancing the ability to perform daily domestic and work tasks promotes autonomy and supports psychological health and social activities in PD.[1,4,5] Thus, we suggest that the increase in muscle strength in our patients may have influenced functional development and quality of life. RTG patients have shown improvements in physical health domains such as mobility and daily life activities, as well as improvements in mental and social health domains, namely stigma, cognition, and communication. Therefore, within a non-pharmacological treatment for PD, RT can positively impact non-motor symptoms of PD.[1,5,30] Non-motor symptoms associated with poor mental health greatly affect the patient's life, such as isolation, depression, and low self-esteem, which are often neglected in the PD treatment.[5,33]

Limitations and future directions

The limitations of the study were the small convenience-based sample consisting of patients with mild to moderate PD according to the Hoehn and Yahr scale. Thus, the results may not be applicable to patients with more severe impairments. Additionally, in studies involving physical exercise interventions, it is not possible to prevent patients from interacting with physical education professionals who guide their exercise routines. There was no control or monitoring of dietary intake during the intervention of the study.

For future research, it is necessary to increase the sample size to confirm the findings with more robust and statistically powerful data. Moreover, we suggest implementing a follow-up study to determine how long the benefits of low-volume RT persist for individuals with PD. Finally, further studies are recommended to assess the efficacy of increased muscle strength and physical performance after RT on motor and non-motor symptoms in individuals with PD.

CONCLUSION

After eight weeks of intervention, resistance training has increased the muscle strength of upper and lower limbs and also improved functional performance and quality of life of moderate PD patients. Therefore, we suggest that resistance training should be part of the non-pharmacological treatment to reduce the functional impairment caused by the progression of Parkinson's Disease.

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