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ORIGINAL ARTICLE

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Low-volume resistance training improves the functional capacity of older individuals with Parkinson's disease

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Aim: To evaluate the effects of low-volume resistance training on the physical and functional capacity of older patients with Parkinson's disease.

Methods: A total of 54 patients (aged ≥60 years) were randomly divided into two groups: (i) a control group comprising 13 men and 14 women; and (ii) a resistance training group with 14 men and 13 women. The resistance training group, in addition to maintaining their pharmacological treatments, carried out 6 months of resistance training twice a week, whereas the control group maintained their pharmacological treatments. Handgrip strength, flexibility, aerobic endurance, gait speed and balance were assessed in both groups.

Results: After 6 months, patient functionality in the control group was reduced, whereas patients who carried out low training volumes showed significantly improved flexibility (Pre × Post: $P = 0.008$), aerobic resistance (Pre × Post: $P = 0.006$), gait speed (Pre × Post: $P = 0.006$) and balance (Pre × Post: $P = 0.043$). Significant improvement ($P = 0.042$) was also observed in right handgrip strength in the resistance training group.

Conclusions: The results of the present study showed that low-volume resistance training improves the physical capacity of older people with Parkinson's disease. Therefore, we suggest that resistance training be a central component in exercise programs for patients with Parkinson's disease. **Geriatr Gerontol Int 2019; 19: 635–640.**

Keywords: elderly, functional capacity, locomotor rehabilitation index, Parkinson, resistance exercise.

Introduction

Parkinson's disease (PD) is a progressive neurodegenerative disorder manifested by the loss of dopaminergic neurons of the substantia nigra pars compacta. Individuals with PD present mainly motor symptoms, including tremor, joint stiffness, progressive bradykinesia and postural instability.[1] PD decreases the ability to carry out daily living activities, leading to dependence on a caregiver.

PD motor symptoms directly influence the functionality of these patients, and it is difficult to treat these motor symptoms applying only pharmacological approaches. Patients with PD at this stage (dependence on a caregiver) are more likely to develop hypokinetic diseases and musculoskeletal disorders (e.g. sarcopenia).[2]

Physical exercise is probably the most promising intervention among non-pharmacological approaches for treating PD. Studies have shown that resistance training (RT) can improve the motor symptoms and functional capacity of patients with PD.[3,4] However, although it is known that training time greatly influences physical and functional performance, few studies have carried out long-term RT intervention in elderly PD patients, with the majority lasting approximately 12 weeks.[5,6]

Therefore, long-term interventions with RT are required to attenuate the motor symptoms of PD. To the best of our knowledge, just two studies have reported the effects of long-term interventions (≥24 weeks) on the functional capacity of older adults with PD applying RT (66 sets per week; 2 × 8–12 repetitions, 11 exercises, twice a week).[3,7] In contrast, our RT program consisted of five exercises (20 sets per week, 2 × 8–12 repetitions, twice a week).

The hypothesis was raised that 6 months of low-volume RT improves the functionality of elderly PD patients. Functionality can be defined as the integral development of biomotor capacities (e.g. strength, balance, gait speed). PD progression reduces several aspects of functionality,[8] including motor, physiological and behavioral aspects.[9] Thus, the aim of the present study was to assess the effects of low-volume RT on the functional capacity (gait speed and balance) and physical characteristics (strength, flexibility, aerobic endurance) of elderly PD patients.

Methods

Study design

This research was approved by the ethics research committee (CAAE: 43624015.6.0000.5173) according to resolution 466/2012 of the National Council of Research Involving Human Beings. All participants signed a Free and Informed Consent Form.

The study participants were PD patients (Hoehn and Yahr stages 1–3) able to meet specific physical and mental parameters with no history of RT in the past 3 months. The exercise group participants completed 24 weeks of RT while maintaining their pharmacological treatments. The control group continued the standard pharmacological treatment for PD (24 weeks).

For randomization, the participants were assigned a number between 1 and 54, and a research analyst not involved in implementing the study carried out the allocation using a publicly accessible official website designed for research randomization (https://www.randomizer.org). Outcome assessors were masked to the group allocation. Randomization (stratified by sex) resulted in a parallel group design with a 1:1 allocation ratio.

Participants

Initially, 68 individuals enrolled in the PD Patient Association in the state of Pará, Brazil, were selected. The inclusion criteria for the study were as follows: (i) PD diagnosis by a neurologist specialized in movement disorders, according to the clinical criteria proposed by Gelb *et al.*;[10] (ii) aged ≥60; (iii) stage 1–3 on the Hoehn and Yahr scale; (iv) stable use of medication (patients could not change the drug dosage during the study); and (v) participants could not have participated in any exercise protocol in the previous 3 months.

Participants were excluded if they presented a Mini-Mental State Examination score of <24,[11] unstable cardiovascular disease or any other uncontrolled chronic condition that would interfere with the safety and conduct of the training and testing protocols or result interpretation. After assessing the inclusion and exclusion criteria, 54 patients were randomly distributed into two groups: (i) a control group (CG) comprising 13 men and 14 women; and (ii) a resistance training group (RTG) comprising 14 men and 13 women (Fig. 1).

Assessments

One familiarization session was carried out to reduce the learning effect. After 48 h, retesting was carried out in the same order (the Tinetti mobility test [TMT], 6-m walking speed test, Timed Up and Go [TUG] test, handgrip strength, sit-and-reach test with Wells' bench, and a 2-min step test) at the first assessment and after the training period.

All evaluations were carried out by a blinded evaluator who was unable to distinguish participants from both groups (blind evaluation). All patients were analyzed during the ON state of their medication (1–1.5 h after taking the medication). All patients were advised to maintain their current medication schedules during the study period.

Anthropometric assessment

Body mass was measured with an analog scale at a 100-g resolution (Filizola, São Paulo, Brazil). Body fat percentages were estimated using a skinfold caliper (Harpenden, London, UK) according to the standard set by the Siri equation[12] using the body density regression model (g mL^{-1}) for three skinfolds as proposed by Jackson *et al.*[13]

Unified scale for the assessment of patients with PD

PD patient deficiencies were monitored based on the Movement Disorders Society Task Force on Rating Scales for Parkinson's Disease.[14] The scale is composed of four components: part I (mental activity, behavior and mood), part II (daily living activities), part III (motor examination) and part IV (therapy complications).

Functional autonomy assessment

2-min step test

Aerobic endurance was assessed by applying a 2-min step test. In this test, the maximum number of knee elevations that the individual could carry out in 2 min was recorded. To measure the number of elevations, one knee was chosen as the reference. The minimum height that the knee should reach was determined to be the midpoint between the patella and the iliac crest.[15]

Sit-and-reach test with Wells' bench

Shoes were removed, and the soles of the patient's feet were placed flat against a box. Both knees should be locked and pressed flat against the floor, and the tester might assist by holding them down. With palms facing downwards and hands facing each other or side to side, the target approaches the length of the measuring line as much as possible, ensuring that his/her hands remain at the same level and one hand does not reach beyond the another. After some

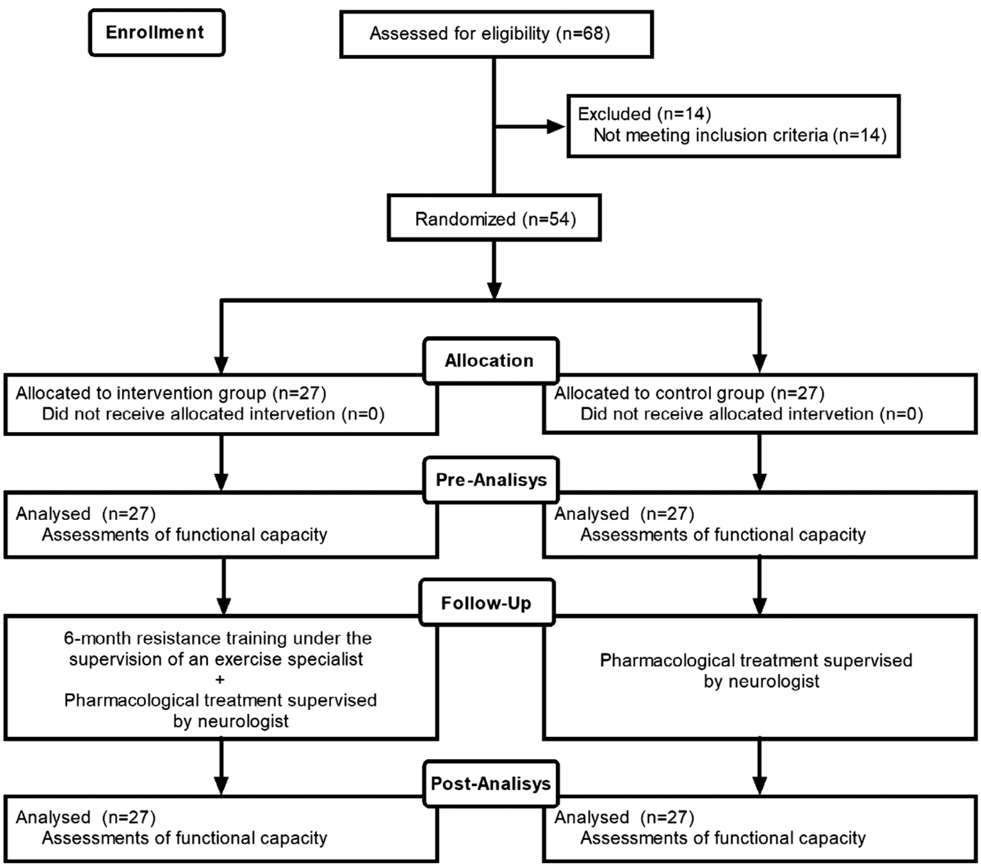

Figure 1 Study flowchart.

practice, the participant held that position for at least 1–2 s while distance was recorded. No sudden movements should be made.[16]

TUG test

With a chair fixed to the ground, one cone was placed at a distance of 3 m. The participant began the test sitting on the chair with his/her feet on the floor and their back against the chair. With the "Go" sign, the individual stood up, went right, moved around the cone, back to the chair and sat down again. Without any hesitation, the individual then carried out the same movement to the left. This test was carried out in triplicate, and the shortest time was recorded.[15]

6-m walking speed test

The individual was oriented to stand in the orthostatic position with legs together and feet touching the starting line. The participant began the test after the verbal command of "start walking", and he/she walked as fast as possible, without running, a marked path of 6 m. The stopwatch was triggered when the individual's foot passed the starting line. Each test was carried out three times, and the shortest time (in seconds) needed to cover each distance was recorded. The seconds were then converted into a walking speed of meters per second (m/s).

Handgrip strength

All participants carried out the test while sitting, and the handle of the dynamometer was adjusted if necessary. When ready, the participant squeezed the dynamometer with maximum isometric effort, and maintained for approximately 5 s. No other body movement was allowed. This test was carried out in triplicate (for each hand), and the best value was recorded. The participant was encouraged to give maximum effort.[17]

TMT

The TMT was used to assess the patients' ability to walk and maintain balance. The total TMT scale consists of a balance scale TMT-B and a gait scale (TMT-G). Each item is scored on a 2 or 3-point scale, resulting in a maximum score of 28, with maximum scores of 12 and 16 on the TMT-G and TMT balance scale, respectively. The TMT score subdivides patients into three groups depending on fall risk and dependency level. The highest-risk group achieves the lowest scores (≤18). The moderate-risk group comprises people with scores ranging 19–23 points, reflecting moderate dependence and fall risks. The minimal risk group scores ≥24 points.[18]

Resistance training protocol

The 6-month exercise intervention program consisted of RT sessions lasting 30–40 min, two non-consecutive days per week, under the supervision of an exercise specialist (1:5 coach to volunteer ratio). The RT program was implemented using a combination of free weights and machines. All sessions consisted of two sets of eight to 12 repetitions of each of the following exercises: bench press (machine), deadlift (barbell), unilateral rowing (machine), standing calf raise (machine) and abdominal reverse crunch. These exercises involve the major muscle groups of both the lower and upper limbs, and simulate the basic daily activity movements. The interval between sets and exercises ranged from 1 to 2 min. During the first 2 weeks, exercise familiarization (motor learning) was carried out. After this phase, training loads were adjusted following American College of Sports Medicine recommendations,[19] and increased 2–10% when the participant was able to carry out 12 repetitions in all sets of a given exercise in two consecutive training sessions presenting a full motion range. In addition, the following characteristics were observed: tendency for concentric muscle failure and co-contraction, rhythm reduction, apnea and Omni scale (score 7–8, hard).

Statistical analysis

Based on the results of a pilot study showing a large effect size (ES; Cohen's f = 0.25) of RT on functionality, the sample size was 22 participants (power of 0.90 and an α of 0.05. Thus, a sample of 68 was recruited to avoid the risk of losing patients throughout the study (G*Power v. 3.1.9.2, 1992; Kiel University, Kiel, Germany).

The data were analyzed using the SPSS v.20 statistical software (SPSS Inc., Chicago, IL, USA). The α level for significance was set at $P < 0.05$, and all tests were two-tailed. The Shapiro–Wilk test was used to analyze data normality. Due to normal data distribution, the aerobic endurance, balance, handgrip strength, maximum walking speed, flexibility, and rising from a chair and moving around results are presented as the mean ± standard deviation. The Hoehn and Yahr scale and Unified Parkinson's Disease Rating Scale scores are described as medians and interquartile range (25–75th percentiles), as these scores were not normally distributed.

Differences between groups at baseline were analyzed using the Mann–Whitney test (variables presenting non-normal distribution) and the *t*-test (variables presenting normal distribution). Intervention effects were analyzed using a 2 × 2 (group by time) repeated-measures analysis of variance. The magnitude of the pre- and post-intervention effects for each group was estimated by calculating the ES.

The intraclass test correlation coefficients were 0.86 (aerobic endurance), 0.84 (balance), 0.89 (right handgrip strength), 0.93 (left handgrip strength), 0.90 (6-m walk test), 0.93 (flexibility) and 0.95 (TUG test).

Results

Study participant characteristics are presented in Table 1. No significant differences in variables between the groups at baseline were observed.

Regarding the RTG, significant increases were observed in flexibility (pre = 24.87 ± 7.42, post = 29.39 ± 6.44, $P = 0.008$, ES = 0.31), aerobic endurance (pre = 75.26 ± 16.06, post = 95.65 ± 19.19, $P = 0.003$, ES = 0.50), TUG test (pre = 17.7 ± 4.5, post = 14.6 ± 3.7, $P = 0.018$, ES = −0.35) and maximum walking speed (pre = 1 ± 0.27, post = 1.2 ± 0.3, $P = 0.006$, ES = 0.33). However, the CG showed decreases in flexibility (pre = 20.6 ± 5.3, post = 19 ± 5.5, $P = 0.008$, ES = −0.14), aerobic endurance (pre = 75.8 ± 13.3, post = 69.3 ± 10.7, $P = 0.003$, ES = −0.19), TUG test (pre = 18 ± 4.4, post = 18.7 ± 4.3, $P = 0.018$, ES = 0.08) and maximum walking speed (pre = 0.96 ± 0.21, post = 0.89 ± 0.19, $P = 0.006$, ES = −0.17; Fig. 2a–d).

The right handgrip strength increased significantly (pre = 24.87 ± 7.42, post = 29.39 ± 6.44; $P = 0.042$, ES = 0.31) in the RTG (Fig. 3a). However, data from the CG showed a significant decrease in the right handgrip strength (pre = 25.02 ± 5.60, post = 23.33 ± 5.02; $P = 0.042$, ES = −0.16; Fig. 3b) during the study period. No significant change in left hand strength was observed both in the RTG (pre = 24.43 ± 7.44, post = 26.80 ± 5.87, $P = 0.313$, ES = 0.17; Fig. 3a) and in the CG (pre = 24.90 ± 5.26, post = 23.90 ± 4.06, $P = 0.313$, ES = −0.11; Fig. 3b).

The TMT showed that RTG patients displayed a significant improvement in balance (pre = 9.74 ± 2.12, post = 10.87 ± 2.32, $P = 0.043$, ES = 0.25), whereas CG patients presented a significant decrease in this parameter (pre = 9.52 ± 2.79, post = 8.43 ± 2.52, $P = 0.043$, ES = −0.20). However, there was no significant TMT-G change in both the RTG (pre = 14.00 ± 2.92, post = 14.61 ± 1.75, $P = 0.116$, ES = 0.13) and CG (pre = 14.48 ± 1.86, post = 12.35 ± 2.14, $P = 0.116$, ES = −0.47). The total TMT score was not significantly altered in the RTG (pre = 23.74 ± 4.07, post = 25.48 ± 2.97, $P = 0.214$, ES = 0.24), but a decrease was noted in the CG (pre = 24.00 ± 3.63, post = 20.78 ± 3.27, $P = 0.214$, ES = −0.42; Fig. 4).

Table 1 Patients' characteristics

Characteristic	Control	95% CI	RT	95% CI	*P*-value
Age (years)	64.9 ± 2.32	63.98–65.82	65.2 ± 2.05	64.39–66.01	0.1541*
Fat weight (kg)	16.6 ± 4.26	14.31–17.69	15.5 ± 3.97	13.93–17.07	0.7577*
Lean weight (kg)	55.3 ± 4.93	53.35–57.25	56.1 ± 9.74	52.25–59.95	0.4836*
Body fat (%)	22.2 ± 4.94	20.25–24.15	23.1 ± 5.46	20.94–25.26	0.4579*
Waist (cm)	94.4 ± 7.71	91.35–97.45	85.6 ± 8.64	82.18–89.02	0.2122*
Hip (cm)	99.8 ± 6.27	97.32–102.28	99.3 ± 24.35	89.51–109.09	0.6708*
Abdomen (cm)	104.4 ± 8.81	100.91–107.89	100.8 ± 9.73	96.95- 104.65	0.1452*
Weight (kg)	70.25 ± 8.33	66.95–73.55	69.43 ± 9.99	65.48- 73.38	0.7309*
Height (cm)	163.66 ± 7.20	160.81–166.51	160.44 ± 9.07	156.85–164.03	0.1411*
BMI	26.39 ± 16.50	19.86–32.92	27.81 ± 15.35	21.74–33.88	0.1496*
H&Y	2 (1–3)	–	2 (1–3)	–	0.2731*
UPDRS – Part I	11.5 (8–17.3)	–	13.5 (7.7–18.5)	–	0.4437†
UPDRS – Part II	19 (15.3–20.8)	–	18 (14–20.7)	–	0.9815†
UPDRS – Part III	30 (28.5–39.8)	–	29 (23.75–39)	–	0.6761†
UPDRS – Part IV	2 (0–4.5)	–	4.5 (1–7)	–	0.8892†
UPDRS – Total	65.5 (57–74.8)	–	66.5 (56.5–75.7)	–	0.7103†
Drugs					
Levodopa + carbidopa	5	–	5	–	NA
Prolopa	100	–	100	–	NA
Benserazida	25	–	25	–	NA
Sifrol	0.18 ± 0.06	–	0.19 ± 0.06	–	NA
Biperideno	146.3 ± 25.5	–	157.4 ± 33.1	–	NA

*Independent *t*-test. †Mann–Whitney *U*-test. BMI, body mass index; CG, control group; H&Y, Hoehn and Yahr scale; NA, not available; RTG, resistance training group; UPDRS, Unified Parkinson's Disease Rating Scale.

Discussion

The main result of the present study shows that low RT volume improves the physical and functional capacity of older patients with PD. RT was carried out just twice a week, but was efficient in promoting improvements in right handgrip strength, flexibility, aerobic endurance, gait speed and balance. In contrast, after 6 months, the CG showed a significant decrease in flexibility, aerobic endurance, gait speed and balance. All tests applied herein simulated activities of daily living for patients with PD and are recognized worldwide, having been applied in several studies regarding functionality and independence analyses.[20–22]

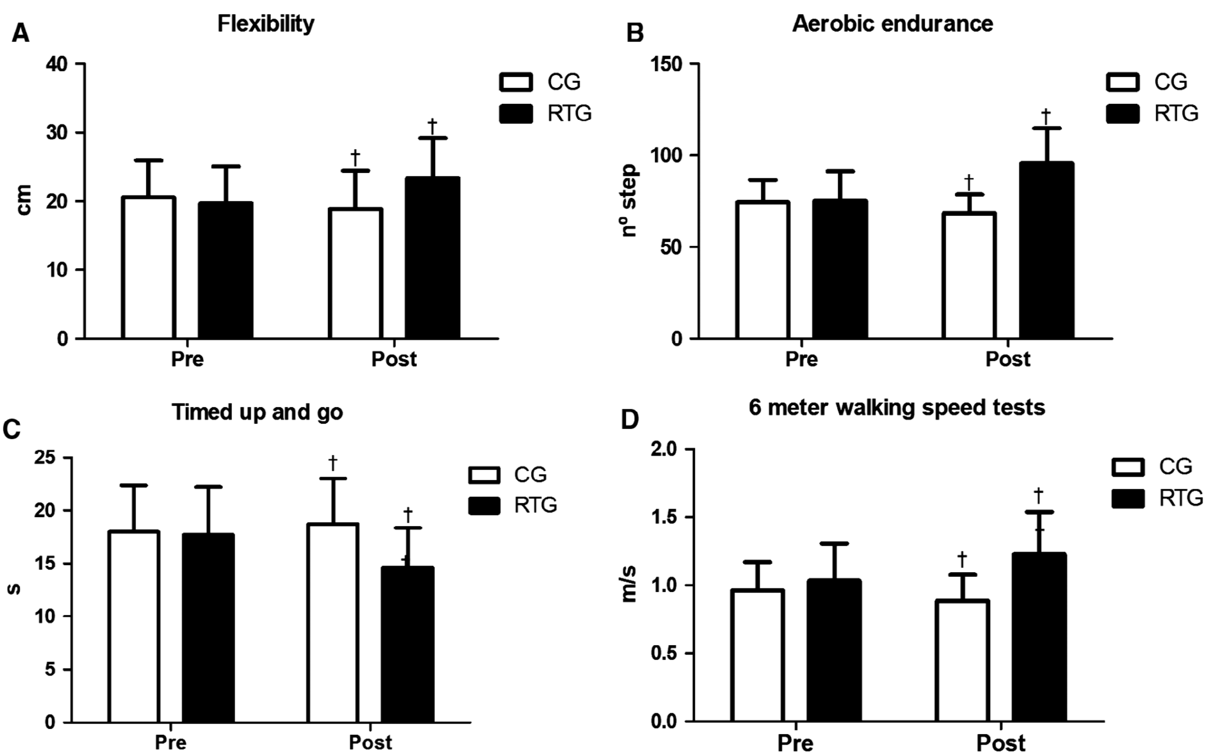

Figure 2 Parkinson's disease patient functional autonomy assessment of the control group (CG) and resistance training group (RTG). (a) Flexibility (group [CG × RTG], $P = 0.002$; time [Pre × Post], $P = 0.008$; group × time, $P < 0.0001$). (b) Aerobic endurance (group [CG × RTG], $P < 0.0001$; time [Pre × Post], $P = 0.003$; group × time, $P < 0.0001$). (c) TUG test (group [CG × RTG], $P = 0.024$; time [Pre × Post], $P = 0.018$; group × time, $P < 0.0001$). (d) Maximum walking speed (group [CG × RTG], $P = 0.001$; time [Pre × Post], $P = 0.006$; group × time, $P < 0.0001$). †Significant difference for the RTG after 6 months ($P < 0.05$).

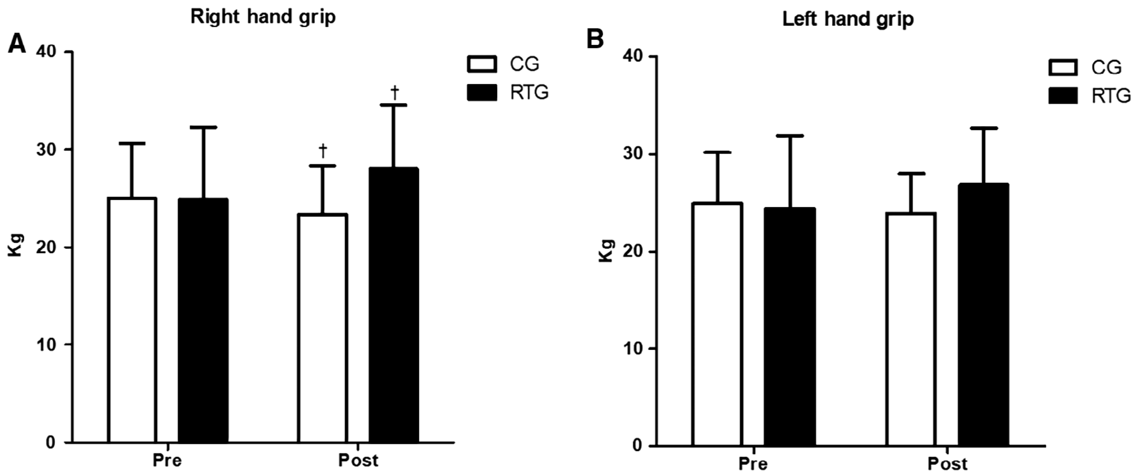

Figure 3 Parkinson's disease patient strength assessment of the control group (CG) and resistance training group (RTG). (a) Right handgrip strength (group [CG × RTG], $P = 0.009$; time [Pre × Post], $P = 0.042$; group x time, $P = 0.008$). (b) Left hand grip strength (group [CG × RTG], $P = 0.565$; time [Pre × Post], $P = 0.313$; group × time, $P = 0.151$). †Significant difference for the RTG after 6 months ($P < 0.05$).

The results of the present study corroborate those reported by Hass *et al.*, who evaluated the effects of RT (two sets of 8–12 repetitions) twice a week on 10 PD patients.[20] The authors showed that patients presented improved muscle strength and gait initiation performance after 10 weeks of training. It has been hypothesized that increased gait speed might be related to improved intramuscular (synchronization, frequency and number of recruited motor units) and intermuscular coordination (more coordinated activation of agonist muscles and less activation of antagonist muscles).[23]

Patients with PD have been reported as presenting difficulty in carrying out daily living tasks.[21,22] In the present study, RTG patients showed significantly increased handgrip strength, flexibility, aerobic endurance, gait speed and balance in relation to CG patients. The increases in these different functionality aspects allow for less dependence and reduce the difficulty of carrying out daily tasks. These findings gain more relevance when assessing elderly PD populations, as functionality improvement is a necessary factor for patient survival.

Decreases in aerobic endurance, gait speed and balance make it difficult to carry out simple daily tasks, such as walking, climbing stairs and carrying small objects, especially for older people with PD. The adoption of an active lifestyle including physical training protocols is effective in improving these physiological parameters.[24] In the present study, RT improved aerobic endurance (2-min step test), balance (TUG test) and TMT-G. The increase in leg strength is postulated as aiding older adults to work at lower percentages of their peak strength with a given workload, thereby using anaerobic mechanisms to a lesser degree.[25] In contrast, the CG experienced significantly reduced aerobic endurance, gait speed and balance.

A tonic inhibition of the thalamus and a reduction of the excitatory impulse to the motor cortex as a result of nigral dopaminergic deficit occurs in PD. This disorder leads to impairments in the recruitment of motor units, and contributes to bradykinesia and muscle weakness. RT has been proposed as an effective intervention aimed at reducing muscle weakness, bradykinesia and balance problems.[1,26] Several studies have shown the efficacy of strength training in improving lower limb strength,[27] gait[4,28] and balance in PD patients.[29]

In the present study, the RTG showed a significant improvement in the balance (TMT balance scale), gait (TMT-G) and total TMT scale indices in relation to the CG. Decreased lower limb strength is related to decreased balance and a decreased ability to respond to postural changes, which can lead to falls and fractures. Therefore, RT was therapeutic in relation to balance and gait.

With advancing age and PD progression, a significant decline in the flexibility of these patients is observed, resulting in a decrease in movement amplitude and daily living activities. Herein, the RTG showed a significant improvement in hamstring flexibility in relation to the CG. Some studies suggest an increase in elasticity during RT that occurs in muscles under tension.[1,5] In addition, joint movement is related to morphological elements, such as muscle, bone and connective tissues. For example, connective muscle tissue proliferation occurs during muscle hypertrophy.

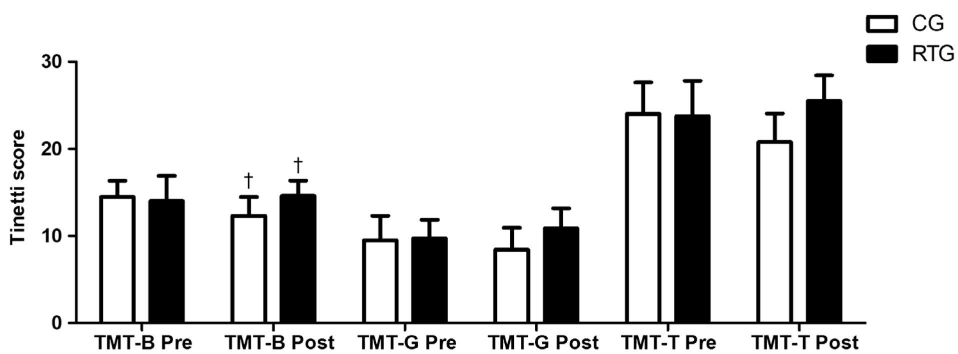

Figure 4 Parkinson's disease patient gait and balance assessment of the control group (CG) and resistance training group (RTG). Tinetti mobility test balance scale (TMT-B; group [CG × RTG], $P = 0.953$; time [Pre × Post], $P = 0.043$; group × time, $P = 0.001$). TMT gait scale (TMT-G; group [CG × RTG], $P = 0.065$; time [Pre × Post], $P = 0.116$; group × time, $P = 0.005$). TMT total score (TMT-T; group [CG × RTG], $P = 0.073$; time [Pre × Post], $P = 0.214$; group × time, $P = 0.456$). †Significant difference for the RTG after 6 months ($P < 0.05$).

Previous findings have also shown that RT is able to improve the activities of daily living, as well as flexibility.[5] Low flexibility values have been related to a higher incidence of injuries, especially spinal injuries, and to greater difficulties in walking and autonomously carrying out daily living activities.

The present study presents some limitations, including the fact that it is not possible to generalize that the established protocol presents the same efficacy in patients in a more advanced PD stage (Hoehn and Yahr stages ≥4). In addition, this study is part of a longitudinal project, and clinical and biochemical parameters are only assessed in follow-up studies.

In conclusion, the results of the present study show that low-volume resistance training improves the functional and physical capacity of older people with PD. Therefore, it is suggested that resistance training should be a central component of exercise programs for patients with PD.

Disclosure statement

The author declare no conflict of interest.

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