The Effect of Therapeutic Exercise on the Clinical Picture and Quality of Life of Patients with Parkinson’s Disease: A Narrative Review and Update of Evidence-Based Physiotherapy Practice

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ABSTRACT: Background: Parkinson’s disease is a degenerative neurological disease that affects a large part of the global population. Exercise has been shown to have a positive effect on people with Parkinson’s disease. However, the appropriate type of exercise requires further investigation.

Aim: The purpose of this narrative review was to present the most recent and up-to-date data on the implementation of resistance and endurance exercise programs in patients with Parkinson’s disease and to provide information on the parameters and content of the programs based on evidential practice.

Results: This review was based on the findings of recent clinical studies and systematic reviews applied to patients with Parkinson’s and related to the implementation of resistance training programs or endurance exercises individually or in combination with other types of training.

Conclusions: Resistance exercises seem to be the most promising type of training in Parkinson’s patients. However, better results seem to derive from combination protocols, where resistance exercises are combined with endurance and balance exercises. The effects of exercise relate to both the treatment of motor disorders of the disease and factors related to quality of life. More studies are needed in the future on larger samples in order to investigate the most effective therapeutic combination.

KEY WORDS: Parkinson, resistance exercise, aerobic exercise, proprioception exercise, physiotherapy, rehabilitation

I. INTRODUCTION

Parkinson’s disease is a progressive neurodegenerative disease of the central nervous system, which involves the loss or dysfunction of dopamine neurons in the brain, as well as the formation of abnormal particles/proteins, called Lewy bodies.1,2 It was first described by James Parkinson in 1817 and is now the second most common neurological
disease after Alzheimer’s disease,³ with a worldwide prevalence of 7 to 10 million people.⁴ It is estimated that more than six million individuals worldwide have Parkinson’s disease.⁵ Degeneration concerns the dopamine cells of the midbrain substantia nigra, which are also related to the onset of the motor disorders of the disease.⁶

Symptoms of the disease include bradykinesia, stiffness, resting tremor, postural instability (loss of postural reflexes), and “freezing” of movement.⁷,⁸ These symptoms lead to a decrease in the functional ability of patients with Parkinson’s, difficulty in walking and performing the activities of their daily life.⁹,¹⁰ Patients are often prone to falls and impending injuries.¹¹ Approximately 68% of patients with Parkinson’s over 60 will experience a fall per year, while 46% will suffer recurrent falls.¹² The number of falls and the probability of injury that accompanies them increases with age as the disease progresses. Fall fractures are the second most common cause of Parkinson’s patients being admitted to hospital.¹³ Fear of falls, which is a psychological consequence of falls, impacts daily life, because it creates a dependency on care providers.¹¹,¹⁴ Parkinson’s patients exhibit a higher fear of falls than healthy people.¹⁵,¹⁶

In addition to motor disorders, the clinical picture of the disease includes general symptoms such as sleep disorders, behavioral changes, depression, and anxiety.¹⁷–¹⁹

In the early stages of the disease, dopamine (L-DOPA) administration temporarily improves motor disorders. However, as the disease progresses, bradykinesia and imbalance gradually worsen and the patient does not respond to L-DOPA treatment.²⁰–²⁵

Physiotherapy plays an important role in treating the symptoms of the disease, contributing significantly to maximizing functional ability and minimizing secondary complications.²⁶ The cornerstone in the recovery of these patients is therapeutic exercise.²⁷–²⁹ Research has shown that therapeutic exercise can help slow the motor manifestations of the disease by reducing motor disorders¹⁶,²³,³⁰ and improving balance,¹⁶,²⁴,³¹ functional ability,²⁴,³²,³³ and quality of life of Parkinson’s patients.¹⁰,²⁴

Many different types of training such as resistance training,³⁴–³⁶ proprioception training,⁹,¹⁶ core stabilization training,³⁷,³⁸ etc., have been administered either individually or in combination and have been investigated for efficacy in patients with Parkinson’s disease. However, although the effect of exercise in patients with Parkinson’s is unquestionable, the appropriate choice of therapeutic exercise combinations as well as the parameters of exercise are factors that require further investigation.³²,³⁹ The aim of this narrative review is to present the most recent and prevailing data on the implementation of exercise programs for patients with Parkinson’s and to provide information on the parameters and content of the programs based on evidential practice.

II. BENEFITS OF EXERCISE AND EXERCISE PRESCRIPTION RECOMMENDATIONS

A. Resistance Training

Resistance training has been suggested by many researchers as an effective therapeutic approach to Parkinson’s patients as it has a positive effect on reducing motor disorders...
related to the disease and at the same time helps to treat non-motor disorders such as sleep disorders and daytime dysfunction, as well as the level of stress. In the systematic review of Chung et al., the researchers report that moderate intensity progressive resistance training, 2–3 times per week over 8–10 weeks can result in significant strength, balance and motor symptoms gains in people with early to moderate Parkinson’s disease. Research has also shown that increasing strength also helps to improve endurance associated with increased walking ability, thus contributing significantly to improving the functional level of these patients and improving their quality of life.

In their research, David et al. wanted to study the effect of progressive resistance exercise on the bradykinesia of patients with Parkinson’s. The researchers studied the electromyographic characteristics of the flexors and the extensor muscles of the elbow when performing ballistic movements of the upper limb. Their study was based on the fact that the electromyographic signal of triphasic potential observed during ballistic movement shows significant deficits in patients with Parkinson’s compared to the healthy population. Based on the fact that the characteristic of triphasic agonist and antagonist muscle activation pattern during ballistic movement in patients with Parkinson’s is impaired, the researchers studied the effect of progressive resistance exercises over a period of 24 months. Forty-eight patients with Parkinson’s disease were divided into two groups. In one group (active control group) a conventional exercise program proposed by the National Parkinson Foundation was implemented and included stretching, balance and breathing exercises, which were performed without difficulty grading, while in the second group (intervention group) a progressive resistance exercise program was implemented. A metal rod with a handle was used to measure the speed and the maximum isometric force (moment of inertia 0.14 kg m²) that rotated freely in a horizontal plane, around an axis that was centered at the elbow joint. The researchers concluded that progressive resistance exercise had better result in the speed of movement of the upper limbs, compared to the group of the conventional program. The researchers reported that progressive resistance exercises partially restored triphasic potential and increased the speed of elbow flexors and extensors. They concluded that progressive resistance exercise improves upper limb movement velocity and restores some aspects of the triphasic EMG pattern.

Ramazzina et al. performed a systematic review of clinical trials applied to Parkinson’s patients containing strength training protocols with external resistances. External resistance included free weights, resistance bands, water, pulleys, etc. The results showed that in most of the studies analyzed, there were positive effects. The researchers concluded that resistance exercises are an appropriate training method to improve both motor manifestations and secondary parameters related to the quality of life of patients with Parkinson’s disease. However, it seems that the effect of this type of training on balance is limited, as the data obtained from their research were contradictory.

A more recent study found that resistance exercises work best when combined with unstable devices. Silva-Batista et al. conducted a study on the effectiveness of resistance exercise in patients with moderate to severe Parkinson’s disease. Thirty-nine patients were divided into three groups (two intervention groups and one control group).
The first two groups followed a resistance training program twice a week for 12 weeks, but only one group used unstable devices when performing the exercises. The third group did not receive any treatment and was the control group. The exercise protocol applied included exercises in the following order: half squat, latissimus dorsi pulldown, plantarflexion, chest press, and leg press. Initial training load was adjusted throughout the sets to allow patients to perform between 10 and 12 repetitions maximum. Whenever participants acquired the ability to do the maximum predefined repetitions for two sessions in a row, the load was increased by 5–10%. The mean frequency of the electromyographic wave of the quadriceps, the maximum torque, rate of torque development, and half relaxation time of the knee extensors and plantar flexors during maximum ballistic voluntary isometric contractions were evaluated before and after the intervention. The results showed a statistically significant improvement in all the examined variables in the group that performed the exercises with unstable devices compared to the other two groups.

In another study, Ni et al. compared the effect of power-based resistance training with a control group on the bradykinesia and muscle performance of patients with Parkinson’s disease. Twenty-six seniors with moderate Parkinson’s disease were randomly divided into two groups. The first group applied a combined protocol lasting 3 months incorporating two sessions per week of high-speed resistance training combined balance and agility drills, while the second group did not follow any exercise program. Upper and lower limb bradykinesia scores, 1-repetition maximums (1RM) and peak powers on biceps curl, chest press, leg press, hip abduction, and seated calf, and the 39-item Parkinson’s Disease Questionnaire (PDQ-39) for quality of life were assessed before and after the intervention. The intervention group highly improved in the following scores: muscle peak power, 1RM and both upper and lower limb bradykinesia ($p < 0.05$). The control group fell behind in these scores and was only able to match the intervention group in power during the seated calf exercise. Statistically significant changes for the intervention group were found in the daily living activities, mobility, and social support subsections of PDQ-39. Muscle peak power and clinical measure of bradykinesia were not found to be sufficiently linked after the exercise. The researchers concluded that combining high-speed resistance training with balance and agility training improves bradykinesia and muscular performance in elderly patients with Parkinson’s disease.

However, according to the systematic review of Roeder et al., resistance training does not appear to be more effective than other training methods in Parkinson’s patients. For this reason, the authors propose combination protocols where resistance training exercises are only one component of the protocol.

Similar conclusions were reached by Saltychev et al. In their meta-analysis they investigated the effectiveness of progressive resistance training in the rehabilitation of Parkinson’s disease. The authors focused their analysis on the research protocols that included low-repetition progressive resistance training. These protocols incorporated a suitable rest period for recovery and gradually increased the resistance based on the improvement of the force-generating ability. Based on the results of their research, they concluded that there is not enough research data to support the efficacy of this
progressive resistance training protocol in Parkinson’s patients, due to the fact that they did not find it to be better than other training regimes.

Other researchers have applied research protocols comparing resistance exercises with other types of exercise. One such example is the long-term study by Rafferty et al.,\textsuperscript{30} which studied the effects of progressive resistance exercise on gait impairments in people with Parkinson’s disease. The researchers conducted a two-year study in 48 participating patients with Parkinson’s. The participants were divided into two groups. One group followed a progressive resistance program while the second a Parkinson’s-specific multimodal exercise program. Gait velocity, stride length, cadence, and double support time were measured under walking with or without medication and on comfortable or fast speed (four different conditions of walking). After the end of the intervention the results of the research showed that both programs were equally effective. The researchers concluded that long-term involvement in either training method had a positive effect on gait in people with mild to moderate Parkinson’s disease, who did not receive treatment. However, although the gait parameters studied were improved with both programs, the instability did not change significantly despite the long implementation period of the program. This fact has been interpreted by the researchers as the possibility that at some point in the course of the disease, exercise adjustments to resistance are not able to compensate for gait instability.

In another study by Shulman et al.,\textsuperscript{24} the effectiveness of three different types of exercise on gait speed, strength and fitness in Parkinson’s patients was compared. Their research involved 67 people who were divided into three groups. The first group followed a higher-intensity treadmill exercise lasting 30 minutes at 70–80\% of heart rate reserve. The second group followed a lower-intensity treadmill exercise (50 minutes at 40–50\% of heart rate reserve) and the third group followed a program with stretching and resistance exercises (two sets of 10 repetitions on each leg on three resistance machines: leg press, leg extension, and curl). These exercises were performed three times a week for three months. The following were evaluated before and after the intervention: gait speed though the 6-Minute Walking Test, cardiovascular fitness through maximal oxygen uptake per unit of time (VO\textsubscript{2} max) and muscle strength through 1RM strength. The results of the research showed that there was an increase in walking distance in the participants of all three groups without, however, any differences between the groups. Additionally, stretching and resistance exercises were the only ones that helped in the area of muscle strength, improving it by 16\% (p < 0.001). On the other hand, these types of exercise fell behind treadmill exercises in terms of VO\textsubscript{2} max. Both treadmill exercises facilitated a 7–8\% increase in that area (p < 0.05).

Other researchers wanted to study the effectiveness of resistance training in relation to balance exercises in patients with Parkinson’s disease. Schlenstedt et al.\textsuperscript{16} conducted a study to compare resistance exercises and balance exercises in terms of improving postural control in people with Parkinson’s disease. Forty patients with Parkinson’s disease were randomly divided into two groups (resistance exercise group and balance exercise group). Both groups followed the corresponding exercise program for seven weeks with a frequency of twice per week. The following were evaluated before and
after the intervention: Fullerton Advanced Balance (FAB) scale, center of mass analysis during surface perturbations, Timed Up-and-Go Test, Unified Parkinson’s Disease Rating Scale, Clinical Global Impression, gait analysis, maximal isometric leg strength, PDQ-39, and Beck Depression Inventory. The results of the research showed that there was no statistically significant difference between the groups. However, the participants of the resistance program showed after eight weeks slightly increased values of the FAB score in relation to the members of the balance training group. Thus, the authors suggest that there was some weak evidence supporting that small coordinated resistance training might be more effective than balance training.

A positive effect on the symptoms of Parkinson’s disease has been found with the application of mat Pilates exercises. In their pilot study, Cancela et al. wanted to study the effect of a 12-week mat Pilates program (frequency two times a week) on fitness level and quality of life in 16 participants with Parkinson’s disease. The Senior Fitness Test battery and the PDQ-39 score were evaluated before and after the intervention. The results of this research showed that there was a statistically significant improvement in all the examined variables.

In another study, Mollinedo et al. wanted to study the effect of a combination of mat Pilates exercises with resistance bands on the dynamic balance of 26 patients with Parkinson’s disease. The exercise program they implemented lasted 12 weeks with a frequency of two times per week. Twenty-six patients with Parkinson’s disease were randomly divided into two groups (Pilates group and control group). The Timed Up-and-Go, 30-Second Chair Stand, and Five Times Sit-to-Stand tests were evaluated before and after the intervention. The results showed that after the completion of the program there were statistically significant differences between the two groups, with the Pilates group showing greater improvement in all the examined variables compared to the control group.

III. ENDURANCE TRAINING

Endurance training aims to improve cardiorespiratory power and cardiorespiratory endurance associated with VO$_2$ max during exercise. Endurance training can improve cardiorespiratory endurance if the individual is trained in 40% to 85% of VO$_2$ max. Endurance is related to exercise intensity, which is often measured at absolute heart rate (HR), relative HR expressed as percentage of maximum (% HRmax) or metabolic equivalents (MET). The American College of Sports Medicine recommends that endurance training ranges from 55% to 65% of HRmax in the early stages of training and can reach up to 90% HRmax (https://www.acsm.org/read-research/trending-topics-resource-pages/physical-activity-guidelines). Lamotte et al. define low-intensity exercise or general activities as being relatively intense, up to 60% HRmax and not improving cardiorespiratory endurance higher than that threshold. To add to this, according to the Physical Activity Guidelines Advisory Committee Report, activities of moderate intensity are defined as 60–75% HRmax and high-intensity as 75–90% HRmax.
In the systematic review/meta-analysis of Lamotte et al., the effects of endurance exercises on motor and non-motor manifestations of Parkinson’s disease symptoms were studied. The researchers concluded that endurance exercise training improves physical conditioning in Parkinson’s patients. High-intensity endurance exercises enhance cardiorespiratory capacity and endurance by improving gait speed. However, the authors report that endurance exercise training has not been sufficiently investigated and current evidence is too weak for it to be a standard inclusion in Parkinson’s-specific treatment regimens. They also note the need for larger scale randomized controlled trials, in order to assess the merits of endurance training in the motor and non-motor manifestations of Parkinson’s disease and assess its safety.

Another systematic review/meta-analysis by Shu et al. included 18 randomized clinical trials involving a total of 901 patients with Parkinson’s disease and examined the effectiveness of aerobic exercise for Parkinson’s disease. The aerobic exercise protocols of the studies included in this meta-analysis showed great heterogeneity in terms of their duration (from 4 to 64 weeks with an average of 4–8 weeks). The exercises implemented were body weight supported treadmill, gait and step training, aerobic exercise, tai chi, Nordic walking, and dance. The results of their review showed that the balance, gait, and motor-related improvements of aerobic exercise in Parkinson’s patients can be revealed rapidly. They found a problem, however, in the lack of long-term follow-ups in the included studies. Consequently, they noted the need for large-scale randomized control trials with follow-ups, in order to be able to reach a definitive conclusion.

The following tables contain the key characteristics of the systematic reviews (Table 1) and clinical trials (Table 2) included in this review.

**IV. CONCLUSION**

The results of this narrative review reinforce the view of the positive effect of exercise on patients with Parkinson’s disease. Exercise contributes significantly to the reduction of motor disorders, improvement of strength and balance, improvement of gait distance, reduction of stress and improvement of quality of life. Regarding which type of exercise is most effective, the data collected by the researchers seem to agree that resistance exercises are the basic component of exercise programs in patients with Parkinson’s. However, their individual application does not seem to have a significant effect on balance. For this reason, combination programs where resistance exercises are part of the program but are combined with both balance exercises and endurance exercises seem to be more effective. The effect of resistance exercises on balance increases when balance exercises are added to the program or when the exercises are performed in conditions of instability. Another promising choice for exercise programs for patients with Parkinson’s is aquatic exercise programs. The implementation of 4- to 12-week programs of aquatic physiotherapy that combine resistance and balance exercises performed in a pool, with a frequency of two to five times per week, help improve functional ability, balance, and quality of life of patients with Parkinson’s disease. They additionally aid in the reduction of disease-related motor
<table>
<thead>
<tr>
<th>Author</th>
<th>Number of included studies</th>
<th>Number of participants</th>
<th>Type of training</th>
<th>Outcome measures</th>
<th>Results/conclusion</th>
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</thead>
<tbody>
<tr>
<td>Ramazzina et al. (2017)</td>
<td>13</td>
<td>476</td>
<td>Strength training</td>
<td>Motor impairments, Physical parameters, Quality of life</td>
<td>Resistance exercises are an appropriate training method to improve both the motor manifestations and the secondary parameters related to the quality of life of Parkinson’s patients. However, the effect of this type of training on balance is limited.</td>
</tr>
<tr>
<td>Saltychev et al. (2016)</td>
<td>12</td>
<td>183</td>
<td>Progressive resistance training</td>
<td>Activity performance, Physical parameters</td>
<td>There are not enough research data to support the superiority of progressive resistance training compared to other physical training and the use of this technique in rehabilitation of Parkinson’s disease.</td>
</tr>
<tr>
<td>Chung et al. (2016)</td>
<td>7</td>
<td>401</td>
<td>Resistance training</td>
<td>Muscle strength, Physical function, Quality of life</td>
<td>The researchers report that moderate intensity progressive resistance training, 2–3 times per week over 8–10 weeks can result in significant strength, balance, and motor symptoms gains in people with early to moderate Parkinson’s disease.</td>
</tr>
<tr>
<td>Roader et al. (2015)</td>
<td>9</td>
<td>425</td>
<td>Resistance training</td>
<td>Muscular strength</td>
<td>Resistance training does not seem to be more effective than other training methods. The application of combined exercise protocols where the resistance exercises are only a component of the protocol is suggested.</td>
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<tr>
<td>Study</td>
<td>Group</td>
<td>Sample Size</td>
<td>Exercise Type</td>
<td>Impairments</td>
<td>Parameters</td>
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<td>Lamotte et al. (2015)</td>
<td>8</td>
<td>338</td>
<td>Endurance training</td>
<td>Motor impairments</td>
<td>Physical parameters, Quality of life</td>
</tr>
<tr>
<td>Shu et al. (2014)</td>
<td>18</td>
<td>901</td>
<td>Aerobic training</td>
<td>Motor impairments</td>
<td>Physical parameters, Quality of life</td>
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TABLE 2: Characteristics of included clinical trials

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<tr>
<th>Author (year)</th>
<th>Number of participants</th>
<th>Type of training</th>
<th>Number of groups</th>
<th>Program duration</th>
<th>Outcome measures</th>
<th>Results</th>
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<tbody>
<tr>
<td>Mollinedo et al. (2018)</td>
<td>26</td>
<td>Mat Pilates and resistant bands vs. control</td>
<td>2</td>
<td>2 times per week for 12 weeks</td>
<td>Timed up-and-go test Five times sit-to-stand 30-second chair stand test</td>
<td>There were statistically significant differences between the two groups with the Pilates group showing greater improvement in all examined variables than the control group.</td>
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<tr>
<td>Cancela et al. (2018)</td>
<td>16</td>
<td>Mat Pilates program</td>
<td>1</td>
<td>2 times per week for 12 weeks</td>
<td>Senior fitness test battery 39-item Parkinson’s disease questionnaire</td>
<td>There was a significant improvement in all the examined variables.</td>
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<tr>
<td>Silva-Batista et al. (2017)</td>
<td>39</td>
<td>Resistance exercises with unstable devices vs. resistance exercises vs. control</td>
<td>3</td>
<td>2 times per week for 12 weeks</td>
<td>Quadriceps muscle cross-sectional area, root mean square and mean spike frequency of electromyographic signal Peak torque, rate of torque development, and half relaxation time of the knee extensors and plantar flexors during maximum ballistic voluntary isometric contractions</td>
<td>Statistically significant improvement in all the examined variables in the group that performed the exercises with unstable devices compared to the other two groups.</td>
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<tr>
<td>Study</td>
<td>Number of Participants</td>
<td>Intervention Description</td>
<td>Frequency</td>
<td>Methods</td>
<td>Findings</td>
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<td>Rafferty et al. (2017)</td>
<td>48</td>
<td>Resistance exercises vs. active control (specific multimodal exercise)</td>
<td>2</td>
<td>Gait analysis: Gait velocity, stride length, cadence, and double support Unified Parkinson’s disease rating scale</td>
<td>Both groups had positive effects on gait speed in people with mild to moderate disease who did not receive treatment without differences between groups. No effect was found in either group on gait instability.</td>
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<tr>
<td>David et al. (2016)</td>
<td>48</td>
<td>Progressive resistance exercises vs. active control (Stretching, balance and breathing exercises)</td>
<td>2</td>
<td>Muscle activation electromyographic activity of elbow joint muscles Strength elbow flexion torque and elbow extension torque Unified Parkinson’s disease rating scale III</td>
<td>Progressive resistance exercises improve upper limb movement velocity and restores some aspects of the triphasic electromyographic pattern.</td>
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<tr>
<td>Ni et al. (2015)</td>
<td>26</td>
<td>Power-based resistance training vs. control</td>
<td>2</td>
<td>Upper and lower limb bradykinesia scores 1-repetition maximum and peak powers on biceps curl, chest press, leg press, hip abduction and seated calf 39-item Parkinson’s disease questionnaire</td>
<td>Statistically significant improvement in the power-based training group in upper and lower limb bradykinesia score, muscle peak power and PDQ-39.</td>
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<tr>
<td>Author (Year)</td>
<td>Number of participants</td>
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<td>Schelenstedt et al. (2015)</td>
<td>40</td>
<td>Resistance training vs. balance training</td>
<td>2</td>
<td>2 times per week for 7 weeks</td>
<td>Fullerton advanced balance scale</td>
<td>There was no statistically significant difference between the groups. However, the participants in the resistance program showed slightly increased FAB score values after 8 weeks.</td>
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<td>Center of mass analysis during surface perturbations</td>
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<td>Timed up-and-go test</td>
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<td>Unified Parkinson’s disease rating scale</td>
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<td>Gait analysis</td>
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<td>39-item Parkinson’s disease questionnaire</td>
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<td>6-minute walking test</td>
<td>There was an increase in walking distance in all three groups without any differences between them. Also, both treadmill exercises improved V̇O₂ max (more than the stretching and resistance exercises did). Finally, only stretching and resistance exercises improved muscle strength.</td>
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<td>Maximal oxygen consumption per unit of time</td>
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<td>Muscle strength (1-repetition maximum strength)</td>
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disorders. However, most of the systematic reviews included in this review emphasize the need for more studies to be conducted in the future on larger samples in order to avoid conflicting conclusions.

REFERENCES


