Exercise Strategies for Parkinson Disease Management

Spencer Ingoglia, and Barbara Sue Graves
Department of Exercise Science and Health Promotion, Florida Atlantic University, Boca Raton, Florida

ABSTRACT

Parkinson disease (PD) is a progressive and chronic neurodegenerative disorder that compromises both motor and nonmotor functions, ultimately leading to a decline in functional capacity and quality of life. Although the etiology of PD is multifaceted, exercise has shown promising effects in managing PD symptoms and enhancing patient well-being. Although aerobic and resistance exercise demonstrate benefits within this specific population, the exact application of these modalities varies and often differs depending on disease progression and the individual. Although individuals diagnosed with PD are encouraged to exercise, there is still a lack of information pertaining to how to successfully structure physical activity into their daily routine. There are also distinct barriers and motivators impacting their decision to engage in regular exercise. This manuscript offers practical recommendations and personalized exercise guidelines for exercise professionals, empowering them to optimize PD management through targeted exercise interventions. In addition, it offers current information on promoting exercise among patients with PD, specifically to enhance their functional outcomes.

Address correspondence to Spencer Ingoglia, singogli@fau.edu.

INTRODUCTION

Neurological disorders affect millions worldwide, with Parkinson disease (PD) ranking as the second most common disorder after Alzheimer disease (83). PD is a progressive and chronic neurodegenerative disease (72) that presents distinct clinical features, ultimately impairing nonmotor and motor functions (88). These effects result in reduced quality of life, disability, and, in some instances, premature mortality (107,112). Despite being underdiagnosed, approximately 90,000 American adults aged 45 years and older are diagnosed with PD annually (177).

Before receiving a clinical diagnosis, increasing evidence indicates that a range of nonmotor symptoms may appear years, and possibly even decades, before the classic motor symptoms associated with PD (172). These symptoms include anxiety (20), depression (154), anosmia (loss of smell) (14), hypersomnia (daytime sleepiness) (1), rapid eye movement sleep behavior disorder (138), and constipation (153). Several treatments for PD exist, including pharmacological therapies such as dopaminergic agonists and monoamine oxidase inhibitors, and nonpharmacological therapies like cognitive behavioral therapy and mind-body exercises. However, current projections suggest a significant increase in PD cases, with an estimated 1.2 million Americans living with the condition by 2030 (177). The economic burden of PD is substantial, totaling approximately $51.9 billion annually, encompassing direct medical costs, indirect medical costs, nonmedical expenses, and disability income (178). From a disease management perspective, Amara and Memon (8) and Alvarez-Bueno et al. (7) identified physical exercise as a promising approach to managing both nonmotor and motor symptoms, and for improving the quality of life (QOL) in patients with PD.

ETIOLOGY

Although the specific cause of PD remains unclear, the condition is typically defined by the loss of dopamine-producing neurons within the substantia nigra pars compacta (28). As these dopaminergic neurons lose function, movement disorders develop. In 2011, the Food and Drug Administration approved the use of dopamine transporter scans (DaTscans) to assist in objectively diagnosing PD and distinguishing between nigrostriatal dopaminergic degeneration and non-nigrostriatal degeneration (87). Although DaTscans are considered the imaging gold standard, they are still of limited diagnostic value (40). Currently, the clinical diagnosis of PD relies on specific clinical classification criteria (88) that assess the presence of 4 distinct motor symptoms: bradykinesia (slowness of movement),

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resting tremor, freezing of gait, and rigidity (resistance to passive movement). Marsden et al. (109) established that motor symptom onset occurs when approximately 50% of substantia nigra dopaminergic neurons are lost; however, the most cited research estimates that approximately 31% of neurons are lost by the time of symptom onset (53).

Although efficacious therapies exist for the treatment of clinical PD, up to 80 percent of patients with PD will also experience cognitive decline, potentially leading to Parkinson disease dementia (PDD) (86). The onset of PDD occurs with the aggregation of alpha-synuclein and the development of Lewy bodies in the soma of affected neurons (38), which ultimately leads to their death. Research indicates that alpha-synuclein can be released from neurons in both human subjects and animal models (50), and its absorption by nearby neurons subsequently contributes to the spread of the disease throughout the brain, correlating with the progression of PD (50). Consequently, the impact of PD on the central nervous system persists and deteriorates gradually over time. In the management of PD and PDD, exercise has demonstrated benefits for various neurodegenerative disorders and positively influences neurorehabilitation (114), making it a vital component of the overall treatment plan (128). Although the mechanisms mediating these effects remain unclear, increases in brain-derived neurotrophic factor (BDNF) and decreases in proinflammatory cytokines associated with physical activity may contribute to the improvement of PD symptoms (6).

PD development is influenced by various risk and protective factors. According to Belvisi et al. (10), key risk factors include family history of the disease, exposure to heavy metals, herbicides, pesticides, and general anesthesia. Pesticides, particularly paraquat and rotenone, are neurotoxic and have been shown to induce rapid degeneration of nigrostriatal dopaminergic neurons (186). Exposure to heavy metals, such as lead from gasoline and paint, reduces dopamine reuptake, decreases postsynaptic receptor expression and sensitivity, and disrupts the dopamine circuit in the substantia nigra, leading to a dopamine deficiency (70,168). In addition, aging is related to both the onset and progression of PD and is associated with a natural decline in the number of dopaminergic neurons in the brain (102).

Nongenetic risk factors such as diabetes and depression also significantly increase the risk of PD (29). However, these risk factors can be managed through increased physical activity (155,184). Belvisi et al. (10) also highlight tobacco smoking and caffeine consumption as protective factors against PD. Caffeine, in particular, has been shown to enhance the efficacy of certain PD medications (43) and improve markers of gait akinesia–an inability to voluntarily perform clinically perceivable movements (95).

In managing PD, several treatment options exist (131), including pharmacological and nonpharmacological options; however, the side effects of several of these therapies may be poorly tolerated (47,55,89,105,147). For example, deep brain stimulation, a common therapy for PD, can lead to adverse effects such as stroke (147), infection (44), gait disturbances (85,142), and speech impairment (121,174). In addition, Borovac's review (16) highlights several side effects associated with dopamine replacement therapy, including impulse control disorder, daytime sleepiness, postural hypotension, weakness, and dizziness. In a large cohort study of 23,058 patients with PD, 81% reported gastrointestinal disturbances, including nausea and vomiting (13). These symptoms can be exacerbated by dopamine replacement therapy, leading to poor appetite and increased nausea (133), which may reduce energy levels and negatively impact participation in exercise.

The potential adverse effects of these therapies should be carefully considered. Some indications suggest that smoking may have protective effects (108). In a report by Quik et al. (141), nicotine, a consistent component in tobacco smoke, was shown to be protective in models of PD. Nicotine's actions on presynaptic nicotine receptors have been found to regulate dopamine release in the nigrostriatal pathway (140), which in turn influences motor function. These findings provide the basis for the hypothesis that smoking, through its nicotine content, may offer a protective effect on PD. In addition, carbon monoxide, a component of cigarette smoke, has been shown to inhibit cell death (139) and provide potent neuroprotection in an in vitro toxin model of PD (119). Although smoking is not recommended as a preventive measure because of significant health risks (132), its association with reduced PD risk remains remarkably robust.

Research on the positive effects of physical activity on motor and nonmotor symptoms in patients with PD is increasing among researchers, doctors, caregivers, and patients alike. In a 2018 review, Fayyaz et al. (52) established exercise as a potential ancillary treatment that can help manage limitations and enhance activities of daily living in patients with PD. In addition to the generic benefits of aerobic exercise on aging and cardiovascular functions (61), it also improves measures of mood (37) and cognition (160). Improvements in walking cadence and distance and gait parameters have also been demonstrated through treadmill walking and stationary cycling in patients with PD (9). As mentioned, motor symptoms typically appear only after approximately 50% of dopaminergic neurons are affected (45). Therefore, engaging in exercise early may help reduce the burden of nonmotor symptoms, which can occur several years or even decades before a clinical diagnosis.

Despite the established benefits of exercise for adults with PD, fully understanding how to maximize the benefits of exercise in patients with PD remains a challenge. For instance, daily fluctuations in motor and nonmotor symptoms, varying disease progression, and the adverse effects of anti-Parkinson medication–because of dosage, duration, and drug combinations–contribute to a lack of specific recommendations regarding the frequency, intensity, time, and type of exercise for this population.

Although data support the inclusion of aerobic exercise to induce endogenous neuroprotective processes (167), these studies often lack direct transferability. For example, lower body aerobic exercise performed in mouse models of PD enhances dopaminergic neuron activity (99); however, traditional treadmill walking may not be well suited for older adults with severe PD because of potential difficulties in tolerance and safety. To address these challenges, body-weight–supported treadmill walking and robot-assisted gait training may offer safer and more effective exercise options, as they have been shown to improve clinical motor function and kinematic gait parameters in patients with severe PD (11,149).

This article aims to evaluate the effectiveness of aerobic exercise, strength training, and other adjunct exercise modalities in managing both motor and nonmotor symptoms in individuals with PD, based on current literature, to assist exercise professionals in designing tailored exercise programs specifically for patients with PD.

PRESCREENING FOR EXERCISE

To promote safe exercise participation and reduce unnecessary medical testing, the American College of Sports Medicine provides a pre-exercise medical clearance decision-making chart through its Exercise Readiness Questionnaire (143). In summary, patients with PD who do not exhibit symptoms of cardiovascular, metabolic, or renal disease can begin exercising at appropriate intensity levels without requiring medical clearance. However, patients with PD who display such symptoms should obtain medical clearance before starting an exercise program.

In patients with symptomatic PD, having a neurologist, physical therapist, or movement disorder specialist assess the severity of PD is essential. The most commonly used scale to measure and assess the ability of patients with PD to perform daily functional activities, and their symptomatic response to medications, is the Unified Parkinson Disease Rating Scale (UPDRS) (110).

The UPDRS consists of 4 subscales that assess disease severity. Subscale 1 evaluates nonmotor symptoms through questions about cognitive function, memory, depression, and motivation. Subscale 2 assesses activities of daily living by having the examiner ask patients to describe their functionality both with and without medication. Subscale 3 is a motor examination that requires a clinician to observe and rate the motor symptoms of PD, including resting tremor, action or postural tremor, rigidity, bradykinesia, speech, facial expression, posture, gait, transitioning from a seated to standing position, and postural stability. Subscale 4 identifies complications related to therapy. Each subscale consists of multiple questions scored from 0 (none) to 4 (severe). A preintervention UPDRS score helps identify risk factors and determine disease severity, allowing for comparison with post-testing to evaluate the effectiveness of therapy. In addition, understanding disease severity can aid in tailoring the exercise program to the patient's specific needs and limitations. Although the UPDRS scale is administered in a clinical setting, a review of training tapes for the UPDRS subscale 2 (66) and subscale 3 (67) can assist the exercise professional when developing a tailored exercise regimen.

First described in 1967, the Hoehn and Yahr scale provides a simplified method for assessing PD progression (81). A rating system from 0 (no impairment) to 5 (severe impairment) is used to evaluate motor symptoms and disability. Patients with PD classified as Hoehn and Yahr stage 1 or 2 (i.e., indicating less severe symptoms) should follow the exercise guidelines outlined by the American College of Sports Medicine (143). For patients classified as Hoehn and Yahr stage ≥3 (i.e., indicating moderate to severe symptoms), their neurologist, physical therapist, or movement disorder specialist should conduct further evaluation using the UPDRS.

Active patients with mild PD may not experience significant benefits from low- or moderate-intensity exercise and might require vigorous-intensity exercise to see improvements (161). In contrast, patients with severe PD, who experience significant rigidity, tremor, and bradykinesia, may have major limitations in performing vigorous-intensity exercise, making moderate-intensity exercise a beneficial starting point.

Subtle nonmotor symptoms in patients with PD may also pose challenges to exercise, particularly cardiovascular autonomic dysfunction. A common symptom of this dysfunction is orthostatic hypotension, which can lead to dizziness, lightheadedness upon standing, and syncope, which increases the risk of falling. Although its occurrence typically increases with disease progression, Kim et al. (93) reported that orthostatic hypotension may appear early in the disease course.

Given that approximately 60% of patients with PD report falling at least once (4) and that evidence suggests a 10-fold higher probability of falls in patients with PD with orthostatic hypotension (144), prescreening for symptoms of cardiovascular autonomic dysfunction is paramount.

One of the most frequently used scales to assess autonomic dysfunction in patients with PD is the Scales for Outcomes in Parkinson Disease–Autonomic Dysfunction (SCOPA-AUT) (175). The SCOPA-AUT can be administered to assess symptoms related to cardiovascular autonomic dysfunction, including orthostatic hypotension. Gibbons et al. (64) also developed screening questions for suspected orthostatic hypotension. Important questions to consider during prescreening for exercise include: Have you fainted or experienced a fall recently? Do you experience vision or breathing disturbances when standing? Do you feel dizzy or lightheaded upon standing?

Ultimately, patients with PD experience varying exercise recommendations based on disease severity. Patients with PD with mild symptoms (e.g., Hoehn and Yahr stage 1 or 2) may be advised to engage in a broader range of exercises similar to those of an aged-matched non-PD cohort, focusing on aerobic exercise, strength training, and flexibility. In contrast, patients exhibiting moderate to severe symptoms (e.g., Hoehn and Yahr stage 3 or higher) require more tailored programs prioritizing balance, coordination, and functional movements targeted to enhance safety and prevent falls. These individuals may require lower intensity and shorter durations of exercise, with greater supervision from health care and exercise professionals. Regularly assessing and adjusting their exercise regimen will ensure their abilities are accommodated. Overall, exercise strategies should be tailored to the individual and their current stage of disease progression. Table 1 outlines a list of daily checks to assess exercise readiness.

MONITORING AEROBIC EXERTION

When considering aerobic exercise, Bouca-Machado et al. (18) identified that the most commonly prescribed exercise frequency is 2 60-minute sessions per week. However, if well tolerated, patients with PD are encouraged to engage in aerobic exercise as often as possible. Bouca-Machado et al. highlighted heart rate (HR), heart rate reserve, maximum speed, and rating of perceived exertion (RPE) using the Borg scale as the most commonly used measures of exercise intensity.

Although HR is closely associated with exercise intensity in healthy individuals, some patients with PD experience cardiac autonomic dysfunction, which impairs HR and blood pressure control during aerobic and resistance exercise (118,162). Patients with PD also experience specific sympathetic loss in cardiac tissue, which can precede the onset of clinical motor symptoms (71,156). In addition, levodopa, one of the most commonly prescribed medications for PD, has been shown to impair HR and cardiac output (124). These effects create challenges for exercise professionals and patients with PD in objectively measuring their exercise intensity. To address this issue, exercise professionals working with patients with PD should use the Borg RPE scale. The Borg RPE scale is a self-reported measure of perceived exertion, ranging from 6 to 20, that effectively gauges exercise intensity in patients with PD when formal exercise testing is unavailable (136).

A Borg RPE rating of 6 indicates minimal exertion, whereas 20 indicates maximal exertion. The Borg RPE scale effectively assesses exercise intensity without requiring additional equipment, making it easy to apply and monitor. Its user-friendly design allows patients to provide accurate ratings of their perceived exertion, regardless of motor impairments (76,148). Patients with PD interested in performing moderate-intensity aerobic exercise who have gained prior medical clearance can aim to be in the mid-range of the scale (i.e., 13) (15). In accordance with Physical Activity Guidelines for Americans second edition issued by the US Department of Health and Human Services, the Centers for

Table 1
List of daily checks to perform before the day's exercise

List of daily checks	
Symptom check	Ask about current symptoms such as tremors, rigidity, balance issues, or fatigue
Cognitive function	Assess the client's cognitive state to ensure compliance with instructions and ability of the cognitive exercise demands
Pain and discomfort	Inquire about any pain or discomfort experienced since the previous session
Hydration and nutrition	Ensure the client is adequately hydrated and nourished before the session
Medication	When applicable, confirm the client has taken their medication as prescribed
Balance and mobility	Check for any changes in balance or mobility that could affect the upcoming exercise routine
Fatigue levels	Assess the client's energy levels and adjust the intensity and/or duration of the session as needed
Feedback on previous sessions	Review client's feedback or observations from previous sessions to make necessary adjustments
Autonomic dysfunction	Monitor for signs of autonomic dysfunction, such as unusual fluctuations in heart rate, blood pressure, or dizziness and lightheadedness

Disease Control and Prevention, the World Health Organization, the American Heart Association, and the American College of Sports Medicine, adults are advised to engage in at least 150 minutes of moderate-intensity aerobic activity or 75 minutes of vigorous-intensity aerobic activity per week (23,78,143,169). Accordingly, patients with PD should aim for 150 minutes of moderate-intensity aerobic exercise (Borg RPE 11–13) per week. If well tolerated, they may aim to accumulate between 60 and 75 minutes of vigorous-intensity aerobic exercise (Borg RPE ≥ 14) per week. These values are cumulative and can be achieved in short bouts (i.e., ≤ 10 minutes) until longer duration aerobic exercise is well tolerated. Table 2 describes aerobic exercise parameters for persons with PD.

AEROBIC EXERCISE

Clinical onset of PD typically coincides with the loss of approximately 50% of dopaminergic neurons in the brain (109). Although these neurons cannot be directly replaced, aerobic exercise triggers the release of potent neurotrophic factors that promote neuronal repair and plasticity (68), which is crucial for PD management. For instance, Fisher et al. (57) demonstrated that 8 weeks of treadmill training increased dopamine D2 receptor-binding potential, suggesting that exercise has therapeutic benefits through neuroplastic changes in the dopaminergic pathway. In addition, aerobic exercise stimulates the release of BDNF from cerebral endothelial cells, which support neuroprotection, neuroregeneration, differentiation, and neuronal survival (125,130). This makes BDNF a valuable target for aerobic exercise in managing neurological diseases like PD. Although the specific mechanisms underlying the BDNF responses to exercise remain unclear, increased cerebral blood flow (CBF) and oxidative stress because of aerobic exercise may contribute to this response (17). Rooks and colleagues (145) completed a systematic review that analyzed 25 studies to assess the effects of incremental exercise on cerebral oxygenation. They found that although moderate increases in exercise intensity are generally associated with enhanced CBF, glucose, and oxygen delivery, and metabolic waste removal, a very high exercise intensity may reduce CBF.

Patients with PD often experience gait impairments (185), which can limit their ability to engage in moderate-intensity aerobic exercise depending on the exercise modality. Therefore, expanding aerobic exercise options beyond standard treadmill walking to include stationary cycling and rowing is important. Evidence also supports incorporating body-weight–supported treadmill walking as an adjunct therapy to enhance ambulation speed in patients with PD (117).

Although there is limited data on the best situations for applying cycling, and further studies are needed to directly assess the potential benefits of stationary cycling, both recumbent and upright cycling have been shown to improve gait parameters and balance in patients with PD (171). Rowing ergometry is an alternative, if available, offering both aerobic and strength training benefits, engaging nearly all major muscle groups and requiring skilled coordination with a greater oxygen demand compared with cycling or walking. This mode of aerobic exercise helps counteract age-related declines in skeletal muscle mass, particularly in leg extensor muscles (182). Similar to stationary cycling, rowing can be performed in a controlled environment, allowing users to stop safely, as needed, without additional intervention. These features make rowing a safe and effective exercise option for patients with PD.

For patients with PD exhibiting limited lower limb mobility, seated arm ergometry offers an alternative mode of aerobic exercise with similar benefits to lower-body stationary cycling (116). Although the short- and long-term benefits of aerobic exercise often depend on exercise intensity, frequency, and duration (56), considering individual cases of PD is essential when deciding whether to incorporate aerobic exercise and determining the optimal mode and intensity. Regardless of the mode, individuals with PD are likely to experience the associated benefits of exercise as long as the desired frequency and intensity are achieved.

METHODS OF INCORPORATING AEROBIC EXERCISE

In response to moderate-intensity exercise, Zoladz et al. (189) demonstrated that an 8-week intervention involving stationary cycling for 1 hour, 3 times per week at moderate-intensity (60–75% maximum heart rate [HRmax]) significantly elevated serum levels of BDNF and reduced inflammation in patients with PD. Similarly, in 2015, Marusiak et al. (111) examined the effects of cycloergometric interval training on muscular rigidity and serum BDNF levels in patients with PD. Participants were required to engage in 1 hour of moderate-intensity cycling (62–68% HRmax) 3 times per week for 8 weeks, resulting in a training-induced alleviation of muscular rigidity and increased BDNF levels. Aerobic exercise has a distinct impact on both acute and chronic BDNF levels (165).

Table 2
Aerobic exercise recommendations

Aspect	Recommendation
Time	150 min per week of moderate-intensity aerobic activity, or 75 min per week of vigorous-intensity aerobic activity
Intensity	Rating of perceived exertion 11–13 for moderate intensity, rating of perceived exertion ≥ 14 for vigorous intensity
Frequency	2 to 3 sessions per week, or as tolerated

These immediate and long-term changes are associated with improved hippocampal-dependent cognitive abilities in the brains of aged adults (12). In aerobic exercise, high-intensity interval training (HIIT) has significantly increased BDNF levels. Harvey et al. (77) demonstrated the feasibility of HIIT in patients with PD, who engaged in 45-minute sessions 3 times a week for 12 weeks, targeting ≥ 85% of their HRmax in a gym circuit. In a follow-up study, O'Callaghan et al. (126) compared BDNF responses in patients with PD after HIIT versus moderate-intensity continuous exercise. Although BDNF levels did not significantly change from pre- to postsession, they were notably elevated after 12 weeks of HIIT compared with both moderate-intensity continuous exercise and control groups.

When designing an aerobic exercise protocol, exercise professionals should consider incorporating longer bouts of moderate-intensity continuous exercise lasting approximately 1 hour or shorter HIIT sessions lasting approximately 30 minutes. HIIT involves alternating periods of intense effort and recovery, typically with a work-to-rest ratio of 2:1. During the work phase, patients with PD should aim to exercise at an intensity of 70–85% of HR_{max} or 14–17 on the Borg scale for durations ranging from 30 seconds to 3 minutes, followed by a recovery interval targeting approximately 55% of HR_{max} or 11–13 on the Borg scale. Each session typically consists of 6 to 8 intervals within the 30-minute timeframe. Workloads can be modified weekly based on input from the exercise professional, patient feedback, and objective and subjective measures such as HR and RPE. For example, when a patient reports lower perceived exertion or displays a lower HR for a given workload, exercise intensity can be increased. This increase can be achieved by augmenting the total number of intervals, extending the duration of the work phase, reducing the rest time, or increasing the workload through adjustments in speed, power, or % of HR_{max}. When determining adjustments, increases in intensity typically range from 3 to 5%; however, the exact time-course and which metric is increased will depend on the individual's ability and readiness.

Higher intensity exercise can also be achieved through forced intensity, which has been shown to stimulate neural activity in patients with PD, particularly in the brain regions responsible for motor control and sensory integration. In 2016, Shah et al. (158) recruited 27 patients with mild to moderate PD to perform forced exercise using a specialized motor-driven pedal system that augmented their pedaling cadence. Participants were instructed to maintain their HR between 60 and 80% of HR_{max} while receiving assistance to pedal at a rate at least 35% faster than their voluntary rate. The 40-minute main exercise set included 2-minute rest periods on the bike every 10 minutes and was performed 3 times per week. After 4 weeks, this progressed to two 20-minute sessions separated by a 2-minute break.

Miner et al. (115) highlighted that the most commonly used exercise frequency in studies investigating the therapeutic effects of forced intensity is 3 times per week. Most studies included a 5- to 10-minute warm-up at a self-selected cadence (40–50 rpm), followed by a 30- to 40-minute main set at a rate of at least 30% greater than the subject's preferred rate, which ranged from 80 to 90 rpm. Among the studies in this review, the optimal training intensity was between 80 and 90 rpm at 60–80% of HR_{max}. Although most studies ranged from 8 to 12 weeks, 1 study (100) indicated that the most significant effects of forced intensity were seen within the initial 5 weeks of the intervention.

In summary, patients with PD should aim to perform aerobic exercise 3 times per week for durations of 30–60 minutes. Exercise intensity will depend on disease severity and the type of exercise, with recommended levels ranging from 55 to 85% of HR_{max} or 11–17 on the Borg RPE scale. All exercise sessions should include both a 5- to 10-minute warm-up and cool-down period because of the prevalence of autonomic dysfunction.

RESISTANCE EXERCISE

The average age of PD onset is approximately 70 years, although a small percentage of individuals experience early onset, with symptoms beginning before the age of 50 (170).

Aging, independent of PD, is associated with degeneration of dopaminergic neurons and is considered the greatest risk factor for developing PD (34). The Rotterdam Study, conducted in the Netherlands, surveyed 7,000 individuals and found the prevalence of PD increased from 0.3% in those aged 55–64–1.0% in those aged 65–74 years, 3.1% in those aged 75–84 years, and 4.3% in those aged 85–94 years (41). Similarly, a census study performed in the United States reported age-associated increases in PD prevalence (177).

Aging is also linked with sarcopenia, a condition characterized by the accelerated loss of skeletal muscle mass, strength, and function (36). Although sarcopenia is common with aging, it occurs more frequently in patients with PD compared with age-matched controls (135,180). The combined effects of aging and PD exacerbate the decline in skeletal muscle mass, strength, and power, contributing to an increased fall risk (181) and a diminished ability to perform activities of daily living (164). Specifically, the inability to perform tasks such as tooth brushing, bathing, cooking, and cleaning is related to energy loss, fatigue, and negative emotions associated with PD (49), which can lead to serious long-term health consequences (97).

As PD progresses, individuals exhibit greater motor unit loss (26,27) and disrupted patterns of motor unit recruitment (65,91,92,146). In addition, motor neuron death and neuromuscular junction deterioration associated with aging will likely contribute to functional decline (73,173). To address the decline in skeletal muscle mass, function, and control, progressive resistance training has been recommended as a safe, nonpharmacological therapy to improve muscular strength in patients with PD (150). In a 2-year randomized control trial, Corcos et al. (35) demonstrated clinically and statistically significant benefits in UPDRS scores, indicating the positive effects of progressive resistance training in improving PD motor symptoms. In addition to progressive resistance training, Helgerud et al. (79) subjected patients with PD to maximal strength training performed at approximately 90% of their 1 repetition maximum (1RM) and demonstrated improvements in skeletal muscle force generating capacity and efferent neural drive after just 4 weeks of training. Although combined exercise therapies are more common than isolated resistance training, studies have reported that increases in lower body strength achieved through resistance training alone can improve gait parameters, balance, and functional performance in patients with PD (19,32,35,104,151). Given these benefits, incorporating resistance training as part of a comprehensive treatment plan aimed at enhancing muscular strength and improving overall physical function is recommended.

DETERMINING RESISTANCE TRAINING INTENSITY

Progressive resistance training programs are typically based on an individual's 1RM, the maximum weight a person can lift for a single repetition with proper form. Although evidence from Buckley and Hass supported the inclusion of a 1RM test to accurately assess baseline strength in patients with PD (22), daily variations in symptom severity may adversely affect the reliability of 1RM performance.

Before performing a 1RM test, patients with PD should perform 2 familiarization sessions, separated by at least 48–72 hours. During these sessions, patients should perform two sets of each each exercise to be tested, while the exercise professional provides instructions on lifting techniques and ensures proper form. To prioritize safety, the exercise selection should focus on machine-based exercises rather than free-weight variations. The 1RM protocol and lifting techniques should adhere to the guidelines provided by the National Strength and Conditioning Association (163).

In brief, to determine a 1RM, patients with PD should start with a warm-up using light resistance that allows for 5–10 easy repetitions (79). After the warm-up, a 1-minute rest period should be observed. Next, estimate a warm-up load that will permit 3–5 repetitions. Typically, this involves adding 5–10% for upper body exercises and 10–20% for lower body exercises. After a 2-minute rest period, estimate a near-maximal load for 2–3 repetitions by adding another 5–10% for upper body exercises and 10–20% for lower body exercises. After a 2- to 4-minute rest, increase the load again by the same percentages to approximate the 1RM. If this attempt is successful, provide 2–4 minutes of rest and then attempt a heavier load by increasing 2.5–5% for upper body exercises or 5–10% for lower body exercises. If the attempt is unsuccessful, provide 2–4 minutes of rest and decrease the load by 2.5–5% for upper body exercises or 5–10% for lower body exercises. Additional information on 1RM testing in aging adults, both with and without PD, has been previously described (22,96,166).

When a 1RM test is deemed infeasible, exercise professionals can use a 3, 5, or 10RM test and calculate estimated 1RM values using a training load chart. For example, if a client is able to complete 10 repetitions of the leg press using 150 lbs, the estimated 1RM would be 200 lbs. These multiple repetition maximum tests can estimate a 1RM without the heavy loads required during a traditional 1RM test. For these tests, patients with PD can start by completing 12–15 repetitions and gradually increase the load, following similar guidelines to those used in the 1RM testing outlined above. Unlike 1RM testing, these tests emphasize continuous effort and measure muscular strength and endurance. Table 3 provides a training load chart for estimating 1RM.

CONSIDERATIONS FOR RESISTANCE EXERCISE PROGRAMMING

Corcos et al. (35) recommended that patients with PD engage in progressive resistance training twice per week. This protocol ensures 48–72 hours between resistance training sessions, allowing for adequate training volume (sets × reps × load) and recovery. The severity of motor symptoms will influence the decision to use machine-based exercises, which require less motor control and are generally better tolerated than free weights, such as dumbbells and barbells. If significant balance disturbances or risk of orthostatic

Table 3
Training load chart

Training load chart											
Maximum repetitions completed	1	2	3	4	5	6	7	8	9	10	12
% of 1RM	100%	95%	93%	90%	87%	85%	83%	80%	77%	75%	70%

Adapted from Landers, J. Maximum based on reps. NSCA J 6(6): 60–61, 1984.

hypotension are present, the exercise professional should incorporate exercises that can be performed while seated and minimize transitions from sitting or lying to standing. For instance, a vertical chest press and a horizontal leg press are recommended instead of a horizontal bench press or a vertical leg press. To determine appropriate exercise selection, the National Parkinson Foundation's Fitness Counts exercise program is a valuable resource (33).

Daily fluctuations in symptom severity will also impact the intensity and volume of exercise that can be safely prescribed. If fatigue is a primary concern, it should be assessed before exercising using the Fatigue Severity Scale (122). Before each training session, exercise professionals should discuss subjective fatigue levels and other relevant factors, such as balance and perceived pain, which may affect the client's ability to exercise safely. Developing a daily checklist to assess tremor severity, bradykinesia, fatigue, balance, pain, quality of sleep, and mood can help tailor that day's training session to the client's current condition. In the presence of fatigue or other limiting factors, the training program should be adjusted by reducing the overall volume and intensity to accommodate the participant's needs. In addition, using a resistance training–specific RPE scale enables clients to self-report how challenging their exercises feel (190). This feedback helps exercise professionals monitor fatigue and adjust their workout intensity accordingly. Reductions in RPE are advised when patients report symptom severity that interferes with their ability to perform traditional exercises effectively.

Ideally, exercise selection in older adults with PD should target large muscle groups across both the upper and lower body. For example, Corcos et al. (35) initially had patients complete 1 set of 8 repetitions and gradually progressed to 3 sets of 8 repetitions for each exercise, including chest press, lat pulldown, reverse fly, double leg press, biceps curls, shoulder press, triceps extensions, back extensions, knee extensions, hip extensions, and calf raises. Although the total number of repetitions prescribed may vary, exercises should be performed close to failure while maintaining the desired number of repetitions in reserve and preserving proper exercise form. To avoid injury, as proximity to failure increases, the exercise professional should closely monitor exercise technique and terminate the set before exercise form is compromised.

GUIDELINES FOR DETERMINING REPETITIONS AND REST INTERVALS

Resistance training goals generally focus on 3 key areas: maximal strength, muscular endurance, and hypertrophy. The number of repetitions and the proximity to failure are adjusted according to the specific training objective. For maximal strength, the standard approach involves 1–6 repetitions per set with heavy loads (80–100% of 1RM), maintaining 2–3 repetitions in reserve (80). Muscular endurance training typically uses lighter loads (~50% of 1RM) for 12 or more repetitions per set, with only 0–1 repetitions in reserve (80). For skeletal muscle hypertrophy, 6–12 repetitions per set are recommended, with loads between 65 and 80% of 1RM, allowing for 2–4 repetitions in reserve (80). Muscular hypertrophy is most closely associated with total training volume, so increasing the number of sets performed is crucial for maximizing muscle growth. In contrast, strength development depends more on the intensity of the contraction, so the focus should be on increasing load. Rest intervals between sets vary according to the training goal: 3–5 minutes for strength, ≤ 2 minutes for endurance, and 2–5 minutes for hypertrophy (3,80). Table 4 summarizes progressive resistance training recommendations.

RESISTANCE TRAINING APPLICATIONS

Once the exercise selection is finalized and 1RMs are determined, patients with PD should start with the resistance set at approximately 30–40% of 1RM for upper body exercises and 50–60% of 1RM for lower body exercises (79). This approach allows patients to acclimate to the training and enables the exercise professional to assess and adjust the training focus. During the initial phase of training, patients should start with 1 set of 8 repetitions, to increase to 3 or more sets as they progress. Adequate rest must be provided between sets of each exercise. Although rest intervals between sets of resistance training generally range from 1 to 5 minutes (42), patients with PD may require varying recovery times. Experienced exercise professionals must be able to recognize signs of adequate recovery, such as the ability to perform subsequent sets with minimal declines in performance.

Arbitrary adjustments should be avoided when determining load.

Table 4
Progressive resistance training parameters

Resistance training goal	Repetitions per set	Load (% of 1 repetition maximum)	Repetitions in reserve	Rest interval (between sets)
Muscular strength	1–6	80–100%	2–3	3–5 min
Muscular endurance	≥ 12	≤50–65%	0–1	≤2 min
Muscular hypertrophy	6–12	65–80%	2–4	2–5 min

Progressive overload should be autoregulated, that is, based on the patient's perceived exertion (80). Once subjects can complete the exercise with proper technique and indicate that the exercise is somewhat easy, the assigned load and/or repetitions can be modified to achieve progressive overload (137). Ni et al. (123) concluded that in patients with PD, bradykinesia, muscle function, and quality of life improved with power-based training. Thus, after several weeks, once patients are familiar with the exercises, those targeting power should shift to increasing the speed of the concentric phase of each repetition (123). Velocity-based training (VBT) is another method of power-based training shown to induce positive changes in functional capacity, strength, and power in patients with PD, without excessive loading. After just 12 weeks of VBT performed 3 times per week, Calaway et al. (24) demonstrated improvements in functional performance in patients with PD, as measured by power output, a 5-time sit-to-stand test, 6-meter walk, and both habitual and maximum walking speed. The application of VBT typically involves ≤5 repetitions, focusing on low-force (i.e., 10–30% of 1RM) and high velocity, while maintaining low perceived exertion, such as having ≥6 repetitions in reserve (75,80). Although not required, velocity measuring tools can assist exercise professionals in identifying changes in velocity that indicate when a change in load is needed. Increases in load should be made when all the repetitions for a given exercise are completed with the appropriate movement speed. A decrease in load is advised if a patient fails to complete the intended number of sets using a full range of motion or cannot maintain adequate speed for the given load. Exercise professionals must closely supervise the session to ensure safety and proper load progression.

Maximal strength training is an alternative form of power training that enhances both the rate of force development and neural drive in patients with PD. In as few as 5 weeks of performing 4 sets of 4 repetitions at approximately 90%, Helgerud et al. (79) observed significant improvements in functional performance tests, including the timed-up-and-go test and stair climbing, compared with the control group. In addition, patients with PD in the exercise group reported significantly improved self-perceived functional health. Maximal strength training and VBT are typically performed using multijoint, compound movements such as chest press and leg press.

NEUROMOTOR EXERCISE

Postural instability is a notable clinical manifestation of PD and ranks among its most disabling motor symptoms (129). Given that this symptom shows limited improvement with anti-Parkinsonian medications (21), incorporating neuromotor exercise training as an adjunct therapy for patients with PD becomes particularly relevant. Neuromotor exercise, such as balance training, requires individuals to control and stabilize their body's center of mass during destabilizing movements, often by reducing the size of their base of support (5). In a meta-analysis by Shen et al. (159), balance training, independent of other therapies, significantly improved both short- and long-term postural stability and reduced fall rates in patients with PD. In addition, Gassner et al. (63) demonstrated that 8 weeks of perturbation treadmill training significantly improved gait and postural stability in patients with PD. Complementary neuromotor exercises such as dancing and Tai-Chi are relatively safe and can further enhance balance in patients with PD (74,82,183). Yoga has also been shown to improve flexibility (187) and address psychological and balance disorders in patients with PD (30,48,98). Incorporating Yoga, Tai-Chi, and dancing into a comprehensive exercise regimen can positively impact both postural stability and flexibility in patients with PD.

Cognitive impairment is one of the most common nonmotor symptoms of PD and includes deficits in attention, working memory, executive function, language, memory, and visuospatial abilities. Similar to postural instability, cognitive function declines with the progression of PD and shows limited responsiveness to dopaminergic medications (157). Because cognitive decline is significantly associated with functional disability and reduced quality of life in patients with PD (69), developing strategies to maintain cognitive function as the disease progresses is critically important.

Recent evidence suggests that Nordic walking offers cognitive benefits for patients with PD (134). Nordic walking mimics the motion of cross-country skiing, requiring coordination of both upper and lower body movements, thereby stimulating cortical regions of the brain beyond what is achieved with normal walking (176). In addition to Nordic walking, standing ellipticals or recumbent NuStep cross trainers also provide a style of exercise that involves reciprocal arm and leg movements.

Initially, patients with PD should aim to complete 3 sessions per week, each lasting 35 minutes at moderate intensity (60% HR_{max} or Borg RPE 11–13), to progress to sessions lasting 40–60 minutes at moderate to vigorous intensity (65–85% HR_{max} or Borg RPE 13–17).

Increasingly, boxing is recognized as a beneficial form of neuromotor exercise that also challenges cardiovascular fitness, balance, and upper-body coordination (31). When performed at high intensities, boxing enhances BDNF production, reduces damage to dopamine-producing neurons, and improves dopamine production (120). In addition, incorporating tasks such as reciting punch counts and naming colors or animals while boxing can further enhance the cognitive benefits of the exercise (90,106), making it a unique option for patients with PD who are interested in performing exercises that engage both their physical and cognitive abilities.

In line with the exercise prescription guidelines for patients with PD and previous reports on boxing, a frequency of 2–3 sessions per week, each lasting 90 minutes, seems to offer the most benefit (31). Similar to HIIT, boxing sessions typically involve short, repeated bouts of exercise lasting 1–3 minutes, separated by 1–3 minutes of rest. Initially, exercise professionals can incorporate boxing into traditional exercise circuits to progress to longer, standalone boxing-specific workout sessions.

Notably, a 2023 systematic review and meta-analysis of 21 randomized controlled trials by Kim et al. (94) found that performing at least 60 minutes a day of conventional exercise training (aerobic and resistance training) effectively improves global cognitive function in patients with PD regardless of the presence of neuromotor training. Incorporating neuromotor exercises alongside traditional resistance and treadmill training may compound the benefits, offering a comprehensive approach to managing both motor and nonmotor symptoms of PD and enhancing overall QOL for patients.

VIRTUAL REALITY AND DUAL TASK TRAINING

Virtual reality (VR) technology is an advanced computer interface that creates interactive experiences by engaging multiple senses in real time. VR can be categorized as low immersion, semi-immersion, and full-immersion, based on how deeply patients interact with the virtual environment (62). For example, VR can integrate exercises and cognitive training, making it a promising option for patients with PD (25,54). Freitag et al. (59) highlighted in a systematic review that VR dual-task gait training effectively improves gait function in patients with PD. Similarly, Dockx et al. (46) found that VR training positively affected step and stride length in patients with PD.

Furthermore, Zhu et al.'s (188) meta-analysis, which included 11 high-quality randomized controlled trials, showed VR intervention had a significant moderate effect on overall cognitive abilities, such as executive function and memory, in patients with mild cognitive impairment or dementia. Although more high-quality, large-scale studies are needed to fully validate the benefits of VR training for patients with PD, current evidence suggests that it may enhance both cognitive and motor function. In circumstances where VR training devices are unavailable, patients with PD can still benefit from dual task training (DTT) (60).

DTT combines motor and cognitive tasks within the same exercise, similar to most activities of daily living. Examples of DTT activities include walking while performing mathematical operations or walking while concentrating on larger steps or heel striking. In a randomized controlled pilot study, Yang et al. (179) had patients with PD complete 4 distinct DTTs while walking: (a) gripping a ball using both hands, (b) simultaneously dribbling a basketball with both hands, (c) dribbling a basketball with one or both hands, and (d) dribbling one basketball while simultaneously holding another basketball using the opposite hand. Their results showed that 12 sessions of motor dual-task training reduced gait variability during dual-task walking.

As part of a thrice-weekly, 16-week multimodal exercise intervention, Andrade et al. (39) included 35 minutes of DTT in a 60-minute session. Although the aerobic exercise intensity consistently ranged between 65 and 75% of HR_{max}, the difficulty of the DTT increased every 4 weeks. For example, participants were required to pronounce an increasing number of items, such as the names of animals, fruits, flowers, and people, or to count backward. At the end of 16 weeks, the intervention group improved balance and performed better on dual tasks activities compared with the control group.

These findings support both dual-task motor training and VR training as effective methods for enhancing cognitive and functional parameters in patients with PD. Ostensibly, the method of DTT plays an important role in transferring skills to everyday activities (101). Exercise professionals interested in incorporating DTT should begin with simpler tasks, such as walking while reciting a list, before progressing to more challenge activities, like dribbling a basketball.

Lee Silverman Voice Treatment (LSVT) is a well-established therapy designed to improve speech and motor function in patients with PD (103,113). Hypophonia (soft speech) and bradykinesia (slowness of movement) are among the most impairing symptoms of PD and may benefit from LSVT (58). LSVT-LOUD focuses on speaking loudly and with meaningful effort to increase vocal loudness, while LSVT-BIG emphasizes performing larger gross motor movements to enhance movement amplitude. To address hypophonia using LSVT-LOUD, patients might start by enunciating syllables, such as performing 15 repetitions of saying "ah" loudly and clearly across various pitches for as long as possible and then progress to phrases like "good morning" (58). For increasing movement amplitude across the limbs, exercise professionals can incorporate LSVT-BIG by having patients perform seated stretches, such as reaching from the floor to the ceiling and progressing to taking big steps forward, sideways, or backward (58). Exercise professionals may consider incorporating LSVT alongside DTT as a unique method to target both cognitive and functional parameters in patients with PD.

IMPROVING ADHERENCE TO EXERCISE

Despite the growing body of evidence supporting the benefits of exercise for individuals with PD, a substantial portion of patients still do not engage in regular physical activity. According to findings from the National Parkinson Foundation QII registry study, 56% of patients with PD do not exercise regularly (127). This lack of physical activity is associated with worse QOL, greater physical function impairments, accelerated disease progression, and increased caregiver burden. Therefore, encouraging exercise as a key component of PD management is crucial.

Understanding why some patients with PD adhere to regular exercise while others do not could help design strategies to improve adherence among less active patients. A study by Afshari et al. (2) sought to compare the beliefs and knowledge about exercise, and to assess the barriers and motivators affecting exercise adherence in patients with high (i.e., $\geq$ 3 hours per week) and low (i.e., $\leq$ 3 hours per week) exercise habits. The study found that well-educated patients who exercised regularly were significantly more likely to increase their exercise habits since their diagnosis, whereas low-exercisers were more likely to reduce their activity levels. Both groups reported discussions with their movement disorder specialist about the advantages of exercise, but high-exercisers were notably more likely to believe in the evidence supporting exercise's potential to slow PD progression and improve mood and sleep. Shared motivating factors included having an exercise professional or training partner and support from a neurologist. Notably, low-exercisers also identified group training and short session durations (i.e., $\leq$30 minutes long) as motivating factors. Although barriers such as fear of falling, lack of time, and low outcome expectations have been reported, these were not highlighted as significant barriers to exercise (51). Significantly more common barriers among low-exercisers included lack of exercise companions or motivation, fatigue, and depression.

Hunter et al. (84) supported these findings, highlighting that group exercise not only creates a supportive communal environment but also offers opportunities for social interaction, encouragement, and increased self-confidence–key factors in enhancing exercise adherence. Dance, Yoga, Tai-Chi, and other group exercise formats will likely facilitate enhanced exercise adherence and lead to better functional outcomes associated with exercise, given their inherent social support and engagement aspects. These insights underscore the crucial role of neurologist support in encouraging exercise. They also suggest that promoting participation in group exercise sessions and involving a significant other or exercise buddy can be effective strategies for improving adherence.

CONSIDERATIONS AND PRECAUTIONS FOR TRAINING WITH CLIENTS MANAGING PARKINSON DISEASE

GENERAL PRECAUTIONS

When training clients with PD, obtaining appropriate medical clearance before starting a new exercise program is crucial, especially if symptoms suggest underlying cardiovascular issues. Exercise professionals should be mindful of daily fluctuations in symptom severity and be prepared to adjust exercise intensity and volume according to the patient's current condition. Whenever possible, conduct most of the exercises in one location and minimize transitions from sitting to standing positions.

Before each session, inquire about the patient's perceived balance, pain, and fatigue to tailor the exercise accordingly. Ensure that the exercise environment is safe, free from tripping hazards, and conducive to the patient's needs. Patients should arrive hydrated and well-nourished, and exercise professionals should provide ample breaks to address hydration and nutrition needs. Be flexible with predetermined rest intervals, as these periods may need adjustment based on the individual's recovery and overall condition. Regularly monitor each patient's response to exercise, noting any changes in symptoms or new complaints to make necessary adjustments and ensure progress and safety.

PRECAUTIONS FOR AEROBIC AND RESISTANCE EXERCISE

Exercise programs should be tailored to disease severity. Patients with mild PD may tolerate higher-intensity exercise compared with those patients with moderate to severe PD. Each session should include a 5–10 minute warm-up and cool-down period to manage autonomic dysfunction and prepare the body for exercise. Routinely assess HR and RPE during aerobic exercise and monitor repetitions in reserve during resistance training to ensure the appropriate exercise intensity.

Avoid 1RM testing when unsafe or unreliable because of symptom severity. Instead, consider using submaximal tests (e.g., 3, 5, 10RM) as alternatives. Favor machine-based exercise over free weights to minimize risk and ensure stability, particularly for patients with significant motor symptoms or balance issues. Adjustments in training load should occur gradually, based on perceived exertion and performance, to avoid overtraining and injuries (i.e., avoid increases greater than 3–5% per week). Tailor session length to each patient's capabilities.

SPECIFIC EXERCISE TYPES PRECAUTIONS

YOGA AND TAI-CHI

Modify poses to accommodate limitations, and consider providing balance support or performing yoga near a wall or other stable fixture. Ensure movements are performed slowly and deliberately, avoiding rapid or jerky movements and positions that invert the patient (e.g., forward folds).

DANCING AND BOXING

Select manageable routines for the patient's current physical condition and provide support when necessary. Start with low-complexity, low-intensity routines and gradually increase intensity and cognitive load in a manageable way. Monitor for signs of fatigue and avoid pushing the patient beyond their capacity. Provide support or assistive devices to prevent falls.

DUAL TASK TRAINING AND VIRTUAL REALITY

Start with shorter sessions and gradually increase the duration based on the patient's tolerance. For exercises that combine physical and cognitive tasks, ensure that the cognitive demands do not exceed the patient's current cognitive abilities. Begin with low or semi-immersion VR to assess tolerance, and

Table 5
Sample weekly exercise program

Sample exercise program			
Day	**Warm-up**	**Main set**	**Cool-down**
Monday	5–10 min of low-intensity cycling, walking, or rowing at RPE ≤11 or 50–60% of HRmax	Aerobic exercise: 3 × 10 min of moderate-intensity cycling or walking (Borg RPE 11–13 or 60–75% of HRmax) with 2 min rest between sets	5–10 min of low-intensity cycling, walking, or rowing at RPE ≤11 or 50–60% of HRmax
		Resistance exercise: 1 set of 8–12 repetitions at 70–75% of 1RM of: chest press, lat pull-down, leg press, biceps curl, shoulder press, triceps extension, knee extension, hip extension, calf raises	
Tuesday	5–10 min of low-intensity cycling, walking, or rowing at RPE ≤11 or 50–60% of HRmax	Neuromotor exercise: 35 min of Tai-Chi, yoga, or dancing	5–10 min of low-intensity cycling, walking, or rowing at RPE ≤11 or 50–60% of HRmax
	LSVT-BIG: stepping forward, sideways, and backward using large strides	Dual-task training: walking while reciting a list or performing simple cognitive tasks. Start with 10 min and increase over time	LSVT-BIG: seated stretches, including reaching for floor and ceiling
Wednesday	5–10 min of low-intensity cycling, walking, or rowing at RPE ≤11 or 50–60% of HRmax	Aerobic exercise: 30 min of HIIT on rowing ergometer (6 intervals of 1 min work at Borg RPE 15–17, 1 min recovery at Borg RPE 11–13) with 2 min rest between sets	5–10 min of low-intensity cycling, walking, or rowing at RPE ≤11 or 50–60% of HRmax
	LSVT-BIG: stepping forward, sideways, and backward using large strides	Resistance exercise: 1 set of 8–12 repetitions at 70–75% of 1RM of: chest press, lat pull-down, leg press, biceps curl, shoulder press, triceps extension, knee extension, hip extension, calf raises	LSVT-BIG: seated stretches, including reaching for floor and ceiling
Thursday	5–10 min of low-intensity cycling, walking, or rowing at RPE ≤11 or 50–60% of HRmax	Neuromotor exercise: 35 min of Tai-Chi, yoga or dancing	5–10 min of low-intensity cycling, walking, or rowing at RPE ≤11 or 50–60% of HRmax
	LSVT-BIG: stepping forward, sideways, and backward using large strides	Dual task training: walking while dribbling a basketball or performing simple cognitive tasks. Start with 10 min and increase over time	LSVT-BIG: seated stretches, including reaching for floor and ceiling
Friday	5–10 min of low-intensity cycling, walking, or rowing at RPE ≤11 or 50–60% of HRmax	Aerobic exercise: 30 min of HIIT on rowing ergometer (6 intervals of 1 min work at Borg RPE 15–17, 1 min recovery at Borg RPE 11–13)	5–10 min of low-intensity cycling, walking, or rowing at RPE ≤11 or 50–60% of HRmax
	LSVT-BIG: stepping forward, sideways, and backward using large strides	Resistance exercise: 1 set of 8–12 repetitions at 70–75% of 1RM of: chest press, lat pull-down, leg press, biceps curl, shoulder press, triceps extension, knee extension, hip extension, calf raises	LSVT-BIG: seated stretches, including reaching for floor and ceiling

Table 5 (continued)			
Saturday	5–10 min of low-intensity cycling, walking, or rowing at RPE ≤11 or 50–60% of HRmax	Neuromotor exercise: 35 min of Tai-Chi, yoga or dancing Boxing training: 2–3 rounds of 3 min each with 1–3 min rest between. Incorporate cognitive tasks such as reciting punch counts or naming items, that is, colors, animals	5–10 min of low-intensity cycling, walking, or rowing at RPE ≤11 or 50–60% of HRmax
Sunday	Rest day	—	—

HIIT = high intensity interval training; HRmax = heart rate maximum; LSVT-BIG = Lee Silverman Voice Technique BIG; RPE = rating of perceived exertion; 1RM = 1 repetition maximum.

proceed with caution with full-immersion VR, as it can be overwhelming or disorienting for some patients. Always request patient feedback and observe for any reactions, such as nausea, confusion, or agitation. If such symptoms occur, stop the session immediately and assess the patient's condition.

CONCLUSION

In 1992, Sasco et al. (152) were the first to report a connection between exercise and enhancements in symptoms among patients with PD. Numerous researchers have explored the impact of exercise as an adjunctive and alternative approach to enhance both motor and nonmotor symptoms in patients with PD, with various forms of exercise therapy demonstrating positive effects on these symptoms. Although aerobic exercise is the most widely studied exercise-based treatment and significantly improves motor- and nonmotor symptoms, balance, and gait outcomes, recent evidence supports the addition of progressive resistance training. Balance training has been shown to improve balance and gait proficiency in patients with PD, resulting in decreased risk of falls in both the short and long term. Although progressive resistance training is shown to combat the decline in skeletal muscle function occurring with aging, several diverging methods of strength training exist. The exercise training program design will also be influenced by disease severity, training goals, and the availability of specialized equipment. Personalized programs must be tailored to an individual's limitations while prioritizing safety. In addition to the advice provided by exercise professionals, patients with PD should monitor their exertion levels based on subjective rating scales (i.e., Borg RPE scale and repetitions in reserve) to assist in the modification of their training programs. Autoregulation of training intensity is likely to improve adherence and long-term outcomes. Patients with PD are advised to engage in either 150 minutes per week of moderate-intensity aerobic activity or 60–75 minutes per week of vigorous-intensity exercise. Patients with PD should aim to include at least 2 days of progressive resistance training per week, focusing on all major muscle groups. Although aerobic and resistance training are the most widely supported, dancing, Yoga, and Tai-Chi are beneficial and should be encouraged. To enhance adherence to exercise, patients with PD are often more motivated to engage in physical activity when exercising in a group setting or with a training partner. In addition to general exercise, LSVT-BIG is highly effective in improving motor function and reducing motor impairments in patients with PD. Research indicates that this program helps improve balance, mobility, and overall functional movement.

Similarly, LSVT-LOUD is a proven method for enhancing voice and speech quality, enabling patients with PD to speak with greater volume and clarity. Together, these therapies contribute to improved communication and a better QOL for patients with PD. Although numerous gaps persist in our comprehension of the most effective interventions for PD symptoms, the advantages of consistent physical activity are vast and should not be underestimated. Exercise professionals are encouraged to discuss the perceived benefits of regular exercise with their PD clients and modify exercises as needed. Open communication between exercise professionals and clients is important for building trust, the cornerstone of any social relationship. When patients with PD feel they can trust an exercise professional, they will be more likely to follow their advice, which will undoubtedly lead to greater adherence and long-term training outcomes. Table 5 presents a sample weekly exercise program for patients with PD.

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Spencer Ingoglia, MS, CSCS *is a Graduate Teaching Assistant in Exercise Science and Health Promotion at Florida Atlantic University.*

Barbara Sue Graves, EdD *is an Associate Professor in the Department of Exercise Science and Health Promotion at Florida Atlantic University.*

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