REVIEW

Effects of Exercise on Mobility in People With Parkinson's Disease

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ABSTRACT: Parkinson's disease is a prevalent neurodegenerative disorder for which only symptomatic treatment exists. Gait and balance disturbance is common in Parkinson's disease and is a major contributor to increased disability and decreased health-related quality of life and survival. Balance and gait deficits in Parkinson's disease are notoriously difficult to treat and are not significantly helped by pharmacological or surgical treatment. The last two decades have seen a dramatic increase in the research and clinical interest in using exercise as a treatment for mobility problems in people with Parkinson's disease. With exciting advances in basic science research suggesting neurochemical and neuroplastic changes after exercise, an increasing number of high-quality studies are documenting particular aspects of mobility improving after exercise. Exercise has the potential to help both motor (gait, balance, strength) and nonmotor (depression, apathy, fatigue, constipation) aspects of Parkinson's disease as well as secondary complications of immobility (cardiovascular, osteoporosis). This perspective article focuses primarily on recent evidence on the effects of exercise in improving mobility while highlighting the importance of targeted exercise intervention for maximizing the benefits of exercise. Suggestions for exercise guidelines, adherence issues, and directions for future research are provided.

Key Words: Parkinson's disease; exercise; physical therapy; mobility

Parkinson's disease (PD) is a complex and highly prevalent neurodegenerative disorder characterized by disabling motor abnormalities such as bradykinesia, postural instability, and gait disorders that can lead to falls,[1,2] increased risk of fractures, mobility disability, poor quality of life, and reduced survival.[3] Therefore, it is not surprising that gait and balance impairment in PD is a major contributor to decreased quality of life.[4] Unfortunately current pharmacologic and surgical treatment options for gait and balance disturbances are limited.[5,6] Therefore, there is a pressing need for other (nonpharmacologic) treatment strategies such as exercise to treat mobility impairments in PD. The number of publications addressing exercise for PD has more than tripled in the past decade. Furthermore, several comprehensive meta-analyses, Cochrane reviews, and perspective articles[7–17] have been published on this topic in the past several years. Yet important obstacles remain with regard to methodology and definition of exercise that prevent clear guidelines and conclusions to be drawn from the literature.

The types of exercise strategies studied in PD patients are numerous, and there is overlap in the definition of exercise versus physical therapy, terms often used interchangeably. The American College of Sports Medicine (ACSM) defines *exercise* as a subcategory of physical activity involving planned, structured, and repetitive body movements that are performed to improve or maintain one or more components of physical activity.[18] Physical activity, on the other hand, refers to *any* body movement that is produced by contraction of skeletal muscles that increases energy expenditure and can involve tasks like walking the dog and household chores as well.[18] Physical therapy uses exercise as a modality to facilitate more effective movement; however, it also utilizes other elements, such as cognitive strategies, that are not traditionally considered exercise. For the scope of this

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TABLE 1. Systematic reviews and meta-analyses of the effect of exercise on mobility of PD patients

Review	Intervention	Number of studies	Number of patients	Main outcome measures	Conclusions
De Goede et al (2001)[20a]	Physical therapy	12 (Including 8 RCTs)	349	ADLs, walking speed, stride length, neurological signs	Patients with PD benefit from physical therapy in ADLs and walking ability (walking speed, stride length), but not in neurologic signs.
Deane et al (2001)[21a]	Physical therapy (comparison of techniques)	7 RCTs	142	Motor impairment, ADLs, QoL, depression, adverse effects	Considering the small number of patients examined, the methodological flaws in many of the studies, and the possibility of publication bias, there is insufficient evidence to support or refute the efficacy of any given form of physiotherapy over another in Parkinson's disease.
Crizzle et al (2006)[19]	Mixed exercise	7 (Including 3 RCTs)	578	Physical improvements (ie, axial rotation, functional reach, flexibility, balance, muscle strength, gait, and mobility)	Patients improve physical performance and activities of daily living through exercise.
Keus et al (2007)[14]	Physical therapy	29 (Including 23 RCTs)	Not applicable	Improvements in core areas of physical therapy (such as gait, balance, physical capacity, and transfers)	Level 2 evidence that cueing strategies improve gait, cognitive movement strategies improve transfers, exercises improves balance, and training of joint mobility and muscle power improves physical capacity.
Kwakkel et al (2007)[22]	Physical therapy	23 RCTs	1,063	Improvements in core areas of physical therapy (such as gait, balance, physical capacity, and transfers)	Moderate to strong evidence that PD patients may benefit from task-specific training to improve postural control and balance, gait and gait-related activities with and without cueing, and physical condition improvement by strength or endurance training. Moderate evidence for the value of physical therapy in improving transfers.
Goodwin et al (2008)[13a]	Mixed exercise and qigong	14 RCTs	495	Physical improvements, falls, QoL	Exercise is effective in improving physical functioning, QoL, leg strength, balance, and gait. Insufficient evidence that exercise improves falls and depression.
Lee et al (2008)[23]	Tai chi	7 (Including 3 RCTs)	130	Flexibility, balance, falls	Evidence is insufficient to suggest tai chi is an effective modality for treating PD.
Dibble et al (2009)[11]	Mixed exercise	16 (Including 13 RCTs)	Not applicable	Body structure and function (postural instability), Activation (balance test performance), Participation (QoL/ falls)	Moderate evidence that physical activity and exercise will improve postural instability and balance task performance. Limited evidence to support improvement in QoL outcomes and insufficient evidence that it can affect near-falls and falls.
Mehrholz et al (2010)[15a]	Treadmill training	8 RCTs	203	Gait-related parameters	Patients who receive treadmill training are more likely to improve gait hypokinesia.
Allen et al (2011)[8a]	Mixed exercise, tai chi, dance	16	997	Balance-related activity performance, falls	Balance-related activity performance improved, but no effect on falls. Larger improvement with highly challenging balance training.
De Dreu et al (2012)[10a]	Music-based therapy(gait and dance)	6 RCTs	168	Balance and gait, UPDRS, QoL	Small but significant improvement in Berg Balance Scale, Timed Up, and Go and stride length. Walking velocity only improved in gait-related music therapy.

(Continued)

TABLE 1. *Continued*

Review	Intervention	Number of studies	Number of patients	Main outcome measures	Conclusions
Tomlinson et al (2012)[17a] updated from Deane et al[21]	Physical therapy	33 RCTs	1,518	Gait, functional mobility and balance, falls, clinician-related impairment and disability, patient-related QoL	Compared with no intervention, physical therapy significantly improved gait velocity, functional mobility, balance outcomes, and UPDRS scores (ADL and motor). No effect on falls or QoL.
Brienesse et al (2013)[9]	Resistance exercise	5 (Including 3 RCTs)	225	Muscle strength, functional improvements related to mobility	Resistance training has a positive effect on mobility and strength.

Mixed exercise includes different modalities including treadmill, physical therapy, balance training, and resistance training.
[a]Meta-analysis.
RCTs, randomized controlled trials; ADLs, activities of daily living score; QoL, quality of life; UPDRS, United Parkinson's Disease Rating Scale.

article, we will use the term *exercise* both for exercise according to the ACSM definition and for physical therapy. It is beyond the scope of this article, however, to discuss physical activity. Mobility is defined as the ability of a person to move around safely in many different conditions and environments, and relies upon good control of balance, gait and the ability to change strategies to task and environment.

This is a perspective article for which large systematic reviews and meta-analyses published in the last decade as well as data from randomized and nonrandomized clinical trails are used for the framework of the article. (the search strategy is depicted in the online appendix). An overview of these articles[8–11,14,15,19–23] is presented in Table 1. This table demonstrates that there is evidence that specific balance training, gait training (eg, with treadmill training), and strength and flexibility training are effective for improving mobility in PD. Effects on quality of life or falls, however, are less conclusive.

There Is Solid Evidence That Traditional Exercise Such as Strength, Flexibility, and Aerobic or Balance Training Improves Some Aspects of Mobility

Strength and Flexibility Training

Compared with their healthy peers,[24–26] PD patients have reduced muscle strength (ie, force) and power (ie, force × velocity), both of which have been associated with reduced walking speed,[25,26] walking economy,[27] and postural instability,[26] resulting in a higher fall risk.[1] Reduced muscle strength and power could be the result of muscle disuse, as PD patients are known to be physically inactive.[28] However, there is evidence that decreased muscle strength may be a manifestation of a central nervous system deficit because muscle strength has been shown to improve with levodopa.[26,29,30] A recent review and a recently conducted 2-year randomized controlled trial (RCT) on the effects of resistance training in PD concluded that resistance training increases muscle strength and endurance and is likely to result in improved gait parameters and functional improvements in mobility.[9,31] Limited evidence supports the notion that eccentric focused resistance training may offer more benefit compared with concentric exercises, as eccentric muscle strength is maintained during aging and oxygen consumption is lower.[29] Strength training is also endorsed by the evidence-based guidelines for physical therapy for PD.[14] Furthermore, PD patients have an abnormally flexed posture with resulting shortened flexor muscles such as hip flexors, hamstrings, and pectoral muscles. Trunk and neck range of motion is often reduced, particularly axial extension and rotation.[32,33] Decreased range of motion of the trunk, in particular, is related to function (ie, functional reach[32,34,35]), and both functional reach and gait can be improved by improving available range of motion.[36]

Aerobic Training

A Cochrane review on the effect of treadmill training on gait parameters in PD concluded that treadmill training, independent of load reduction, is likely to improve gait velocity, stride, and step length.[15] Recently 2 RCTs were published that both included more than 25 PD patients per treatment arm. One study compared 16 months of balance training versus aerobic exercise (treadmill, stationary bicycle or elliptical trainer) with stretching (control) and found aerobic exercise to improve physical fitness (walking economy) compared with the other arms, whereas balance training improved Unified Parkinson's Disease Rating Scale Activities of Daily Living (UPDRS ADL) score and physical function.[37] Schulman et al compared 3 months of high- versus low-intensity treadmill training with stretching and resistance exercises and found similar effects on physical fitness with a dose-response relationship (peak VO2), whereas all intervention arms improved in gait speed (6-minute walk test).[38] Significant changes in the UPDRS motor scales, balance (functional reach), nonmotor

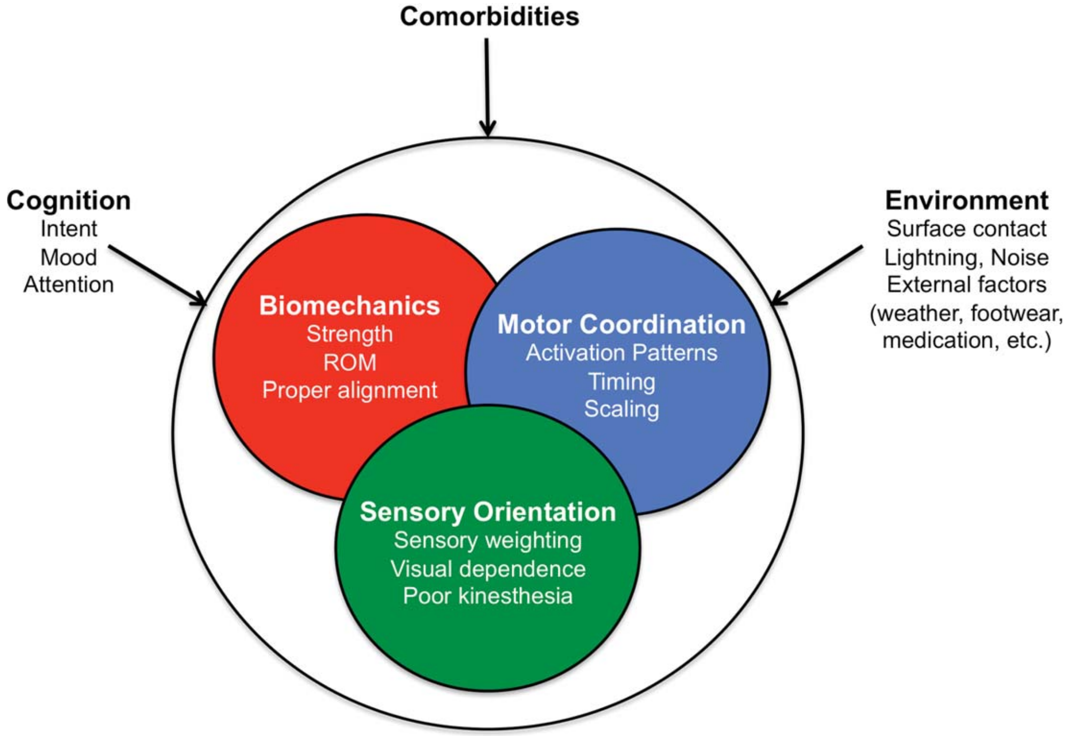

FIG. 1. Integrative functions for optimal mobility; implications for exercise. Mobility disability in people with PD may originate from (1) poor biomechanics such as decreased strength, ROM, or postural alignment; (2) poor motor coordination such as inadequate muscle activation patterns, decreased timing, or scaling of a postural reaction such as anticipatory postural adjustments and/or postural reactions to perturbation; (3) poor sensory orientation such as overreliance on vision for balance and inability to reweight senses quickly for changing visual or surface conditions. Other contributors to poor mobility may be the influence of cognitive, environmental factors and comorbidities.

symptoms, and quality of life were not observed in these studies.

Balance Training

Poor balance is a common and devastating consequence of PD. Recently, several RCTs studying the effect of balance exercises in PD showed that balance exercises, either alone or in combination with other training modalities such as strength, joint mobility, or gait training, can reduce the number of falls[39] and improve balance control,[39] overall physical functioning,[37] postural transfers,[39,40] freezing of gait,[40] and functional reach.[41] Previous reports suggested that the combination of resistance exercises and balance training in PD was more effective in improving balance and postural stability compared with balance training alone.[14,29,42]

However, because of differences in balance exercises, combinations with other exercises, duration and intensity of the exercises, and outcome measures, it is difficult to determine superiority of any of the treatments or added value of different modalities. Furthermore, many balance scales used in trials may be insensitive to the unique deficits found in PD such as difficulty turning[43] or difficulty with dual tasks and may be insensitive to mild balance deficits or mild improvements in balance after training.[44]

Exercise Should Target Specific Underlying Impairments That Affect Mobility

Figure 1 models the complex integrative functions for optimal mobility that should be considered when designing an exercise program for PD. Exercise to improve mobility should be targeted and specific to the aspect of balance or gait control that is impaired. For example, a deficit in the *biomechanical* system (strength, range of motion, proper alignment of joints) requires very different exercise than for deficits in *motor coordination* such as properly sized and executed postural reactions (timing and scaling of reaction). Further, impaired *sensory organization* and problems in sensory reweighting (when conditions of lighting or surface change) require very specific exercise. Finally, functional mobility requires ongoing evaluation of external environmental cues and contexts and the cognitive reserve to maintain attention and handle multiple tasks at once.[45,46] Multiple aspects of the postural control system are impaired in people with PD, and exercise should be specific to the impairment.

Effect of Complex Multifaceted Exercise on Mobility

Given what we know about the complex nature of PD-specific deficits that contribute to poor balance and gait, it is unlikely that one exercise, for example, aerobic training by itself, will necessarily improve balance control adequately.[45] With greater understanding of the multifactorial nature of balance and gait deficits in PD, people have begun to investigate multifaceted exercise such as tai chi, dance, and agility training that may simultaneously target multiple aspects of disability.

Tai Chi

Tai chi, known to improve balance in the elderly, has a strong emphasis on maintaining control of one's center of mass. Tai chi has received attention in the PD community after several RCTs reported the beneficial effect of tai chi for people with PD on postural control compared with no intervention[47] and compared with stretching or resistance exercises.[48] Furthermore, in the latter study, the tai chi group performed better than the resistance training or stretching group in balance and gait measures, and both resistance exercises and tai chi led to a decrease in falls.[48] Tai chi naturally combines slow control of movement, strength, multidirectional movement, and complex sequential action requiring cognitive attention.

Dance

Similarly, dance is receiving attention as an interesting exercise strategy for PD because it naturally combines cueing, spatial awareness, balance, strength and flexibility, and physical activity (or even aerobic exercise if the intensity is sufficient).[12] Moreover, it is enjoyable and stimulates social engagement and peer support. Clinically significant improvements were found in balance, gait, and endurance when comparing the tango, waltz, and fox-trot with traditional exercise interventions.[49–51] An RCT with a 12-month community-based tango program resulted in significant and clinically important reductions in disease severity (UPDRS), balance impairment, and dual-task walking compared with controls. In addition, freezing of gait occurred more in the control group at follow-up, and the 6-minute walk test deteriorated in the control group at follow-up, whereas the dance group remained stable. Interestingly, upper extremity function in the nine-hole pegboard test also significantly improved in the dance group. Together with the improvement in UPDRS motor score, this implies that the effects are transferred to nonrelated tasks and may suggest a disease-modifying effect.[52] Moreover, it shows that long-term exercise treatment is feasible and that it results in an increase in participation in physical and social activities.[53]

Agility Training

King et al developed a sensorimotor agility program in which the predictable constraints on mobility (rigidity, bradykinesia, poor sequential coordination, sensory organization, and freezing of gait) are targeted.[54] The theoretical framework proposed in this article suggests using sensorimotor progressions (ie, visual or surface changes, dual tasks) alongside traditional progressions (speed, intensity) for each exercise. They found that 4 weeks of an intensive agility program improved a greater number of outcome measures regarding balance and mobility when compared with treadmill training alone.[55] This approach is currently being tested in a clinical trial comparing results from home, individual, and group exercise.

Effect of Exercise on Nonmotor Symptoms

Although the primary focus of this article is on motor symptoms related to exercise intervention, it is well known that there are many nonmotor symptoms (NMSs) that may affect mobility (see Fig. 2). PD patients experience a wide range of NMSs, such as sleep disturbances, cognitive impairment, depression, anxiety, apathy, and constipation. These NMSs are already present in the early stages of the disease,[56] sometimes even preceding motor symptoms,[57] and with disease progression they largely contribute to the patients' quality of life.[4] The amount of NMSs is associated with motor disability, reflected in a higher UPDRS motor score and, in particular, to the postural instability gait subtype of PD.[58] Although exercise for PD has the potential to benefit NMSs,[16] very few studies have directly explored this possibility in PD patients. Aerobic exercise has been associated with improvement in executive function, decreased age-related cognitive decline in the healthy elderly,[58,59] improved self-reported quality of sleep and quality of life in older people with insomnia,[60] and reduction in depressive symptoms in older adults.[61] In PD, promising small open-label studies on the effect of exercise on cognition[62,63] or sleep[64] were performed, but confirmation from large RCTs is needed. Also, the prevalence of secondary complications such as cardiovascular diseases and osteoporosis can be decreased by exercise.[16]

These nonmotor symptoms of PD may also be important factors or barriers in successful implementation of exercise. A current study by our group, founded by the foundation for physical therapy, examined the relationship of nonmotor and medical comorbidities as they relate to mobility and success in rehabilitation. Our results show that the number and severity of medical system comorbidity is at least twice as high as the reported norms in the categories of psychiatric, musculoskeletal, and gastrointestinal comorbidities.[65] Furthermore, there were significant correlations between comorbidity and balance ($r = -0.47$; $P = 0.001$), falls ($r = 0.32$; $P = 0.01$), gait ($r = -0.54$; $P = 0.001$), and physical function ($r =$

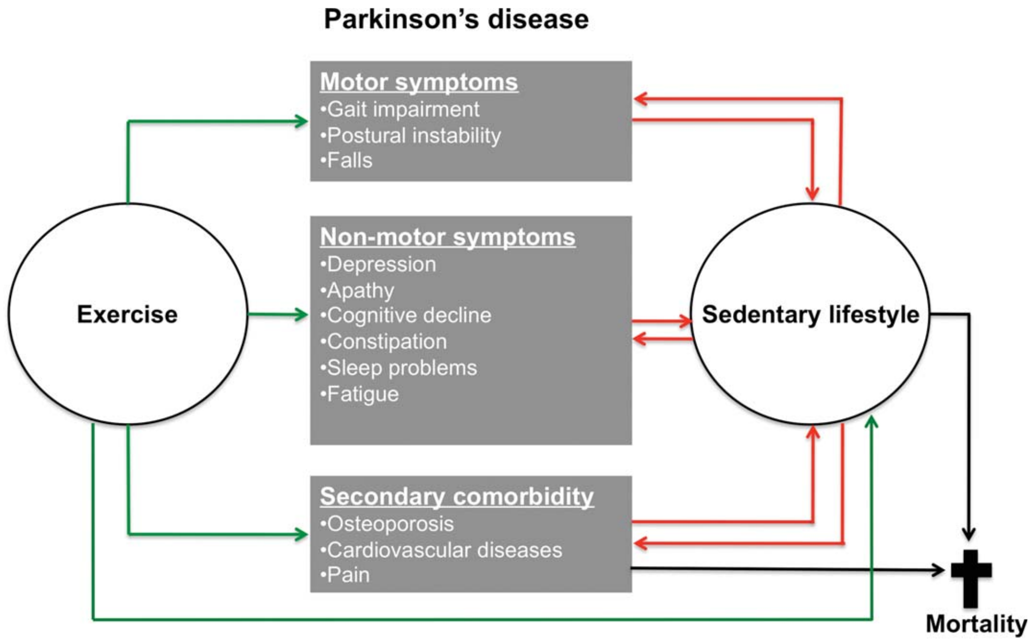

FIG. 2. Effects of exercise on Parkinson's disease. Schematic representation of how exercise intervention may help to break the cycle of decline for both motor and nonmotor symptoms of PD as well as the sequelae of secondary comorbidity and mortality that result from a sedentary lifestyle.

-0.38; $P = 0.002$).[65] Many comorbidities that lead to inactivity[66] such as depression[67,68] and back pain[69] may be helped, both preventively and as treatment, by exercise and should be addressed early on.[70,71]

Exercise-Induced Changes to the Brain

There is strong evidence from the animal literature that aerobic training not only improves functional performance but also creates changes at the level of the brain itself. Experimental rodent models of PD showed that high-intensity aerobic training (1) increases postsynaptic D2 receptor mRNA expression and binding affinity, (2) downregulates the dopamine transporter protein, and (3) reduces glutamate transmission and synaptic strength.[72] Moreover in both the 6-OHDA-lesioned rat and the MPTP-lesioned mouse, high-intensity treadmill running, initiated before, during, or after neurotoxicant exposure, has been shown to ameliorate motor symptoms.[71,73] Neurochemical and neuroplastic changes are less straightforward when studying exercise intervention for humans. Nevertheless, recently a translational pilot study was published in which intensive aerobic exercise in early PD patients resulted in better postural control and increased postsynaptic D2 receptor binding potential on PET imaging with [18F]fallypride.[74] Moreover, functional MRI performed after a single bout of forced exercise revealed the same change in network activation pattern as that seen between medication states.[75] Similar results were observed with transcranial magnetic stimulation after high-intensity treadmill exercise in PD patients in whom reduced cortical hyperexcitability (which is characteristic for the parkinsonian state) was found.[76] Another indirect measure of neuroplasticity in dopaminergic signaling can be provided by changes in levodopa-equivalent dose. One study reported that a 4-week inpatient rehabilitation program resulted in a long-lasting decrease in medication usage over a 2-year period.[77] Generalization of motor learning is another derivative way of looking at cerebral motor plasticity. Although the majority of studies have evaluated motor functions related to the prescribed exercise (ie, walking speed after treadmill walking), some evidence for generalization of motor learning to other functions has been provided. For instance, Alberts and colleagues reported that forced active cycling compared with voluntary cycling performed at a self-determined pace resulted in improvement in upper limb fine motor function and UPDRS motor score.[75,78] Despite the small sample sizes and the lack of a control group, these results raise the fascinating possibility that high-intensity aerobic exercise results in enhanced central motor processing.

Suggestions for Exercise Guidelines in PD

As the scientific evidence regarding the merits of exercise for PD is growing, all PD patients should be strongly encouraged to increase physical activity and exercise regularly. Although PD patients suffer from unique physiological restrictions that require specific attention around exercise, recommendations tailored for PD patients do not exist. Although it remains to be determined what is the optimal type and intensity of exercise for PD, the guidelines provided by the American College of Sports Medicine (ACSM) for older adults (and patients ≥50 years with chronic disorders) could serve as a good starting point.[79] Here we formulate suggestions for exercise in PD patients based on these guidelines[79] together with our view on the aforementioned literature. Although it can be considered a limitation of this article that we did not conduct a systematic review of the literature, there have been several excellent meta-analyses and comprehensive reviews (see Table 1) primarily supporting the evidence of exercise and its relevance to PD management. ACSM guidelines recommend incorporating aerobic, strengthening, flexibility, and balance training. Specifically, aerobic training should be done ≥5 days/week for 30 minutes of moderate intensity or ≥3 days per week for 20 minutes at vigorous intensity. Aerobic exercise goals for PD patients should be set at determined heart rates and not estimated heart rate because many PD patients suffer from chronotropic incompetence (ie, inability of the heart to increase its rate commensurate with increased activity or demand) already early in the course of the disease,[80] and their maximal heart rate is therefore lower than expected. If a maximal aerobic test is unavailable or impossible because of high cardiovascular risk, a submaximal stress test should be performed to establish appropriate training goals. If unavailable, subjective scores on intensity can be used; however, these do not correlate linearly.[79] All PD patients should be encouraged to exercise at their optimal medicated state, as dopaminergic medication allows better, safer, and longer performance of aerobic exercise.[81] The ACSM recommends ≥2 days per week of strengthening (8-10 exercises involving major muscle groups and ≥2 sets of 10-15 repetitions) and flexibility exercises (for ≥10 minutes each time). We recommend adding a strong focus of strengthening the extensor muscles to counteract flexion of the hips and trunk[36,70] and focused flexibility training on the frequently shortened flexor, axial, and cervical muscles.[36] Finally, the ACSM recommends balance training only for those who are at risk for falls. However, many parkinsonian constraints that influence mobility are already present during the early stages of the disease,[41,82] and therefore balance training should begin early on to target such constraints (see Fig. 1). We believe that every PD patient should perform balance exercises and that balance exercise should be adjusted to the specific impairment related to disease stage.

Behavioral Change Strategies and Adherence to Exercise Regimens in PD

Adhering to exercise is a well-known challenge for healthy older adults, but even more so for older adults with chronic diseases.[83,84] Overall adherence rate for short-term (6-week to 24-month) exercise trials is around 80% in patients with Parkinson's disease.[37,82,85–87] Identified factors that influence the adherence rate during short-term exercise programs in PD are older age, low self-efficacy, poor health, mental health problems, and poor sense of control over exercise program.[82,85–88] However, long-term maintenance of an exercise program might even pose a bigger challenge than adherence to an exercise regimen over a short, predetermined amount of time. Few studies have assessed the activity level of their participants after cessation of the trial, and both healthy older adults and PD patients tend to fall back to their pretrial activity level.[84,89] Identified barriers for continuing regular exercise were decline in health, time constraints, and lack of motivation.[89,90] Self-efficacy, lack of motivation, and poor sense of control over exercise behavior can be addressed by promoting active patient participation and engagement, thereby facilitating participatory health and collaboration between patients and health care professionals. Moreover, direct feedback on physical performance gives patients a sense of control over their health and disease and results in positive reinforcement. Exercise regimens should directly address strategies for long-term adherence. For example, the ParkFit trial in the Netherlands used a behavioral change program with coaching to increase and maintain physical activity in sedentary PD patients over 2 years.[87] In the Netherlands health insurance is mandatory and covers permanent physiotherapy consultation (after the 20th consult) for PD. In the United States, however, the number of uninsured patients is much higher, and insurance does not cover exercise classes or continuous physiotherapeutic consultation for PD. Therefore, financial limitations should also be considered.

Exercise-related Risks

There are risks to consider when prescribing exercise for PD patients. In general, an increase in physical activity results in a higher incidence of leisure time and sports-related injuries.[91] This incidence might even be higher in PD patients, as they have an increased risk of falls and fractures[1] and suffer from more frequent musculoskeletal problems.[92] Nevertheless, several trials reported on the safety of their prescribed intervention, and no increases in falls or other exercise-related injuries were found.[8,41,87,93] However, the majority of these studies included independent ambulatory PD patients. Greater risks may apply to PD patients in the more advanced stages, and exercise alternatives should be raised. In the case of extreme freezing, for instance, treadmill aerobic exercise, even with cueing, might be unsafe to practice, whereas the use of a stationary bike could provide a safe alternative.[94] Moreover, the use of stationary equipment is safer and provides the option of exercise at home. General exercise-related risks such as cardiovascular risks should be considered in PD as well, especially when prescribing intensive aerobic exercise in sedentary patients or patients with preexistent coronary artery disease.[92] Moreover, PD patients often suffer from the aforementioned cardiac incompetence, warranting caution when prescribing exercise at an estimated heart rate.

Conclusion and Future Directions

In conclusion, there is great interest in defining best practices for exercise as an intervention for PD that could help both motor and nonmotor complications of PD. There is a growing body of empirical evidence on the beneficial effects of exercise on gait and balance control in PD and several areas of exciting research including exercise-induced changes to the brain. It is important to continue to strive for specific and universally accepted recommendations regarding the frequency, intensity, and type of exercise for people with PD. It is also important for researchers and clinicians to come to a consensus on the most sensitive and meaningful outcome measures in trials to achieve larger power. We strongly suggest an increased role for exercise and rehabilitation at all stages of the disease and believe that exercise should use a wide variety of movements and address many different constraints on mobility. When designing an exercise program for a PD patient, several issues should be considered. (1) The intervention should be targeted to address patient-specific key physiological restrictions. (2) The intervention should be feasible. Unrealistic time-consuming regimens will dramatically influence compliance; however, exercise strategies that cover several areas of physiological restrictions simultaneously or combine several exercises into one training session of approximately 1 hour seem a feasible time consumption. (3) Exercise-related risks should be assessed. (4) Barriers to exercise should be decreased by, for instance, group classes, home exercise, monitoring and treatment of NMSs and comorbidities, personal goal setting, and seeking alternative ways to improve exercise participation on a permanent basis. ■

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