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Review Article

Update on Non-Traditional Exercises in Parkinson's Disease: A Motor Symptom-Focused Approach

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Abstract

The role of exercise in Parkinson's Disease (PD) has been studied extensively in the last decade. Recent evidence shows physical activity partially improves the motor and non-motor symptoms of the disease. In this new era of personalized medicine, it is crucial to better characterize the benefits of exercise in PD. In the present review, we discuss the most recent studies analyzing the clinical effects of various modalities of exercise in PD, including physical therapy, aerobic exercise, strength and resistance training, and nontraditional forms of activity such as tai chi, dancing, aquatics, and boxing. We also provide the primary care physician with expert recommendations based on current evidence and highlight issues that remain unresolved (e.g. the best type of exercise, symptomatic benefits based on different modalities, optimal frequency and duration, and duration of benefit).

Keywords: Exercise; Motor; Non-motor; Training; Parkinson disease; Primary care

Introduction

Parkinson's Disease (PD) is a complex progressive neurodegenerative disorder characterized by a variety of motor and non-motor symptoms [1,2]. The classical motor symptoms are bradykinesia, resting tremor, and rigidity. Postural instability appears as disease progresses. Non-motor symptoms include cognitive impairment, neuropsychiatric manifestations (depression, anxiety, apathy, or psychosis), dysautonomias (Lightheadedness or dizziness from orthostatic hypotension), gastrointestinal symptoms (drooling, dysphagia, gastroparesis, constipation, small intestinal bacterial growth, helicobacter pylori infection, defecatory dysfunction), urogenital manifestations (urgency, frequency, incontinence, sexual dysfunction), sleep disorders (daytime sleepiness, REM behavioral sleep disorder, insomnia, awakenings, periodic limb movements), and symptoms such as fatigue and pain [3].

Treatment of PD is recommended to be in multidisciplinary approach covering all different aspects of the disease. Pharmacologic therapy is the mainstay of treatment. Levodopa remains the most effective drug for motor symptoms, however other drugs such as dopamine agonists, Catechol-O-Methyltransferase (COMT) inhibitors, Monoamine Oxidase Type B (MAO-B) inhibitors, anticholinergics, and amantadine can help ameliorate symptoms [4,5]. A select group of patients with PD may benefit from invasive surgical therapies such as Deep Brain Stimulation (DBS) and ablative procedures, or infusional therapies including continuous duodenal infusion of a carbidopa/levodopa enteric gel and continuous subcutaneous apomorphine infusion [6].

Over the past decades, researchers have extensively examined non pharmacological approaches in PD. These interventions play an important role in the treatment and well-being of PD patients. Speech and swallow therapies are essential in addressing symptoms that can be dangerous (dysphagia causing aspiration) or that can be refractory to oral therapies (hypophonia and dysarthria) [7]. Occupational therapy (OT) can help patients to continue with their daily tasks as disease progresses including mobility, fall prevention, sit-to-stand transfers, bed mobility, posture and seating, eating and drinking, self-care routines, domestic skills, fatigue management, and handwriting. Occupational therapists help evaluate and plan activities of daily living crucial for well-being and independence in PD patients [8].

Physical activity also plays an important role as a non pharmacological approach in PD. Recent works showed that participation in exercise programs is prognostic factor for maintenance of health and function over time in people with PD [9]. Also, studies demonstrated brain imaging changes such as greater activation of ventral striatum and lower apathy and bradykinesia induced by physical activity [1]. We will use the following terms to avoid confusions. General physical activity is defined as any bodily movement produced by skeletal muscles that requires energy expenditure and are done as part of playing, working, active transportation, house chores, casual walking, and recreational activities. Exercise, is a subcategory of physical activity that is defined as a planned, structured, repetitive, and purposeful activity in the sense that the improvement or maintenance of one or more components of physical fitness dedicated to moderate-vigorous caloric output is the objective. Physical therapy or neurorehabilitation are structured programs aimed at rehabilitation

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to develop, maintain, and restore people's maximum movement and functional ability. Physical Therapists (PT) address balance, strength, and range of motion related to the patient's functional mobility. OTs and PTs help prevent disease related complications.

In the present review, we focused the discussion of the literature with the highest level of evidence only regarding the activities related to non-traditional exercises in PD. Non-traditional exercises included in our review were those physical activities not related with original techniques to improve physical health such as running, jogging, bicycling, weight lifting, or gym machinery. An online search was conducted in the database Pubmed using the words "exercise" or "physical activity" and "Parkinson's disease". Only randomized controlled trials (Level 1) and controlled longitudinal studies (Level 2) from the last five years were included in this narrative review. There search studies analyzing general physical activities or neurorehabilitation programs were not included since our aim was to review the evidence of non-traditional exercises. The discussion of the literature was separated based on a motor symptom approach.

General recommendations

In order to maintain a healthy lifestyle, the Centers for Disease Control and Prevention (CDC) recommends people age 65 and above to engage in at least 150 minutes of moderate-intensity or 75 minutes of high-intensity aerobic exercise per week along with muscle-strength training two or more days weekly (Table 1). As PD patients represent a distinct group of people compared to the general population and its variety of phenotypes can affect disease progression and prognosis, we believe a personalized approach of these physical activities focusing on most problematic symptoms would be the best for PD patients. The National Parkinson Foundation Quality Improvement Initiative (NPF-QII) also recommends at least 150 minutes of time for exercise in PD patients older than 65. The NPF further recommends that an important and effective way to protect motor functioning is to use a well-designed exercise plan that will provide benefits associated with mobility, caregiver burden, and everyday activities [11,12].

In this era of personalized medicine, we believe that a well-designed exercise plan should be individualized to each patient needs. To achieve this goal, we need to better understand how the different types of exercises impact PD symptomatology in order to design more individualized exercise programs for each patient.

Non-traditional exercises in PD

Balance and falls: Numerous exercise routines have shown potential benefits on balance of PD patients [13]. Balance is undoubtedly a critical symptom that should be addressed in these programs. An expected manifestation of PD is postural instability, even in early stages of the disease, which can result in falls and fractures. Almost 60% of patients with PD report a fall in the previous year [14]. Not surprisingly, they are five times more likely than their healthy counterparts to develop significant injuries, such as hip and spine fractures [15]. Studies also show that balance can be improved by practicing different types of exercises in combination and is recommended at the onset of the diagnosis. When balance and resistance training exercises are performed and completed together, patients' standing balance improves more when compared to balance training alone [16]. These findings highlight the multifaceted control of balance and suggest that a well-rounded intervention may be needed to maximize benefits. Through a regimen of increasing intensity over time, resistance exercise targeting the ankle plantar flexors, the knee extensors and the knee flexors, decreased patients' bodily sway even when they were presented with disturbed visual and proprioceptive cues [16].

Table 1: Examples of exercise activities recommended by the Centers for Disease Control and Prevention.

Aerobic	Muscle-Strengthening
Walking	Exercises using bands, weight machines,
Dancing	Hand-held weights
Swimming	Callisthenic exercises
Water aerobics	Digging, lifting, and carrying as part of
Jogging	Some gardening
Aerobic exercise classes	Carrying groceries
Bicycle riding (stationary or on a path)	Some yoga exercises
Gardening activities (weeding)	Some Tai chi
Tennis	
Golf (without cart)	

Boxing training-consisting of stretching, running, cycling, plyometric cardio exercises, footwork drills, and punching bag use-resulted in improved balance, mobility, and quality of life [17]. The use of technology or virtual reality exercising (videogame based physical activities) improved balance and fatigue after 12 weeks of gaming, though this was not sustained after 60 days of follow-up [18]. In another study, patients doing tai chi for 10 weeks demonstrated better maximum excursion and directional control, which correlated with decreased sway and extraneous movements, respectively [19]. A general dance regimen over the course of 12 weeks provided improvement in the timed up and go test and the berg balance scale [20], and biweekly "Traditional Argentine Tango" as a more specific dancing intervention improved balance as assessed by the Mini-BES Test [21]. Furthermore, tandem cycling for 180 minutes per week for ten weeks improves static standing balance assessed by the short physical performance battery, which is also predictive of future disability [22]. In general, an increase in berg balance score after tandem cycling indicates a lower predicted fall risk. Exercise can also improve confidence in balance. According to the activities specific balance confidence scale those PD patients who exercise expressed a greater growth in confidence in their balance during the study [17]. This finding is important because persons with PD often have a disconnect between their perception of balance abilities and their actual balance capabilities and reduced balance confidence significantly impacts participation in activities of daily living and social engagement [23].

The effects of aquatic exercises on disease severity and quality of life have also been studied. A recent systematic review of 6 studies reported an improvement on motor symptoms using UPDRS part III, on balance and falls using berg balance scale and falls efficacy scale, on those patients receiving aquatic exercises compared to those with no intervention [24].

Gait: Gait impairment is another expected late manifestation in PD patients. Freezing of gait and festination are common gait problems that can also lead to falls and fractures [25]. In addition to traditional physical therapy-gait training, other types of exercise have proven beneficial to gait impairment in PD patients. At the end of six months, participants in body weight-supported treadmill training completed a 10 meter walk in 1.6 seconds less than those participating in conventional physical therapy [26]. In addition to aerobic training [27], resistance training [28], tango, ballet, or jazz [20], and boxing

training [17] have all increased gait speed and dual task walking speed. Boxing training [17], low intensity treadmill training, and stretching as well as resistance regimens produced significant improvements in walking distances during the 6-minute walk test [27]. Lastly, while tai chi has shown improvement in gait speed in some studies [19], others have failed to show it is a valuable intervention for improving gait initiation [29].

Aerobic exercise via bike and elliptical use also improved baseline walking economy or energy expenditure to a greater extent than flexibility and balance training completed individually and as a group when tested throughout 16 months of engagement [30].This finding highlights the specificity of training is an important feature of exercise program design. The greatest improvements in walking have come from studies that have focused on improving walking abilities. Tandem cycling accelerated gait cadence by 2.27 steps/min in patients with PD Hoehn & Yahrstages 1to 3 who maintained a target cadence of 80 to 90 RPMs during the highest intensity component of a 55 minute workout that lasted 25 sessions [22]. Noteworthy, the intervention focused on cadence was the most pronounced change in gait. Walking with pivot turns improved significantly with Argentine Tango [21]. Aquatic exercise therapy showed improvements in motor disability and revealed similar benefits in gait variability when compared to usual care [31].

Overall motor function: Mobility is affected in early stages of PD and worsens over time. Although pharmacologic therapy is the mainstay for the treatment of motor symptoms, adjuvant traditional physical therapy is recommended to all patients. Studies show clinical improvement in everyday living for patients when combining balance and flexibility training in addition to a physiotherapy regimen [32]. In a recent study, two months of axial control and functional reach training alone and two additional months of balance training in conjunction with the same flexibility routine improved physical function (as measured by the continuous scale-physical function performance) [33] and overall motor function scores as measured by Part III of the unified parkinson disease rating scale [UPDRS-III] [34] for patients with early to mid stage PD. The scores improved not only more than those of the control group, but also more than in those engaging in aerobic exercise alone [30].

Many studies focus on how motor symptoms can improve with exercise. Off-medication UPDRS-III scores showed improvement at 6 months with a regimen of stretching, balance, and strengthening twice per week [35]. Participants had an average 7.3 point improvement on the off medication UPDRS-III between baseline and 24 months and the levodopa equivalent dosage increased by 150 mg per day while the control group increased by 200 mg per day. In fact, improvements were seen in all tests (functional reach test timed up and go test, berg balance scale, six minute walk test, and walking speed assessment) and while both groups required an increase in medication during this time, the increase was not significantly different between the two groups. A regimen challenging lower body resistance, grounded in leg curls, leg extensions, and leg press, followed by both upper and lower body stretching, reduced the UPDRS-III by 3.5 points [27]. Tango dancing also improved motor symptoms in a biweekly tango regimen, which correlated with a 12.8 point (28.7%) reduction in off-medication UPDRS-III at 12 months [36]. Twelve weeks of tai chi improved UPDRS-III scores by two points in people with early PD [37], and high intensity cycling improved UPDRS-III by 16 points and the benefit remained one month after the intervention [38]. Tandem cycling with a partner without PD who maintained the pace throughout the workout resulted in improved functional mobility as measured by the timed up and go test [22].

Certain forms of exercise may produce specific motor improvements. Boxing provides an increase in transition speed, as measured by the timed up & go, and also impacts mobility [17]. Tai chi proved beneficial for increasing movements inherent to activities of daily living, such as functional reach, knee flexion, knee extension, and upper extremity function (assessed by the nine hole peg test) [19]. Cycling resulted in improvement in whole body mobility as measured by the four square step test and the 10 meter walk test [39]. Bimanual dexterity, essential to the coordination inherent in grasping and eliciting strength to open a jar, also increased in the group cycling 30% faster than their counterparts.

Strength: Strength can improve by performing exercises that target specific muscle groups. With both stretching and resistance regimens, people with PD increased their leg strength by 16% [27]. In a smaller study, strength increased with biweekly progressive resistance training for 10 weeks [28]. More specific strengthening exercises for the quadriceps, hamstring, and gastrocnemius muscles with weight and pulley systems increased strength in those muscles by 52% after ten-weeks [16]. Amore extensive progressive strengthening program including chest press, bicep curls, back extensions, and reverse flies for upper body and axial strength, in addition to targeting the major lower body muscle groups, also improved strength (measured by off-medication elbow torque) [35]. In a small study evaluating the effects of therapeutic Tai chi on functional fitness status and activities of daily living, those patients who exercised 2 times a week for 12 weeks demonstrated improvement in upper body strength [37].

Limitations and considerations of current research

Exercise study designs are unavoidably challenged by the inability to have a placebo group. Given reliance on participation, subjects are necessarily aware of treatment assignment, though not necessarily expected outcomes. Using active control groups can limit "placebo" effects occurring in groups assigned to no exercise, but such studies would not reveal whether exercise is better than no physical activity. Having multiple active groups may also obfuscate specific benefits attributable to unique interventions. Multi-component interventions also have strengths and weaknesses. Boxing regimens, for example, include stretching, strengthening, and endurance. This may result in greater improvement but can make it difficult to clarify the direct effects of each modality. Clinicians should also consider that statistically significant benefits reported from exercise on PD might not represent a clinical significance. In addition, the small sample sizes and characteristics of PD patients included in the studies, while positive, may reduce the generalizability to all patients with PD. Many patients in the studies to date had mild to moderate PD, were functional and ambulatory without assistance, and lacked major comorbidities, dementia, or psychosis. It is uncertain whether studies engaging these populations can be generalized to people with more advanced PD.

Other factors impacting study results and generalizability include setting, whether exercise was performed individually, at home, or in group therapy, or if an expert was supervising [40,41]. It is likely that similar types of exercise were performed differently across studies, impacting reproducibility. Exercises are rarely compared head-to-head to investigate optimal strategies, whether overall or for targeting specific symptoms, though some links between approaches and expected benefits are known (Figure 1).

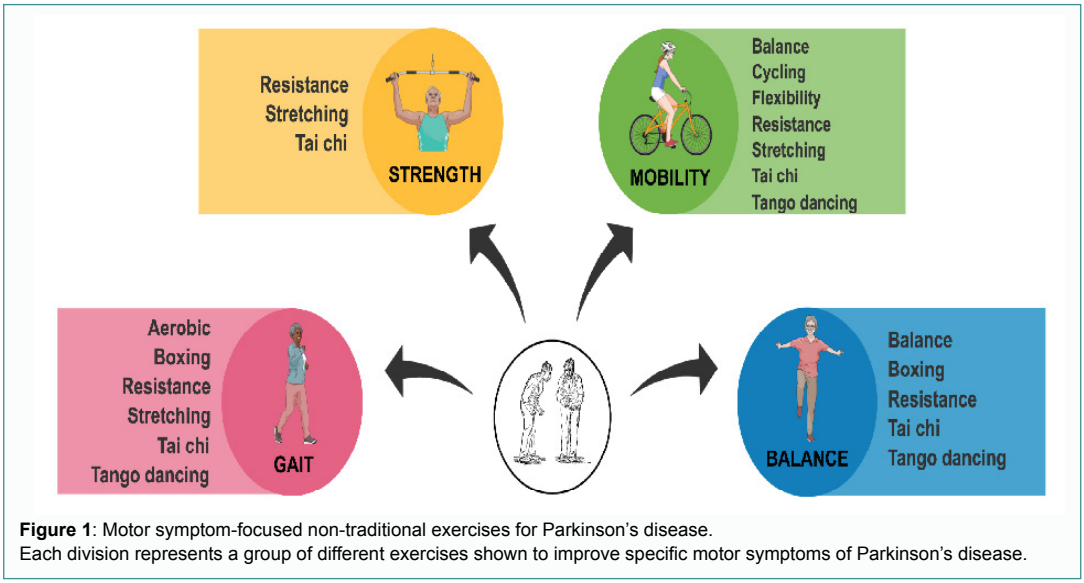

Figure 1: Motor symptom-focused non-traditional exercises for Parkinson's disease.
Each division represents a group of different exercises shown to improve specific motor symptoms of Parkinson's disease.

Physician considerations

Experts in the field of PD and leading organizations agree that any form of physical activity could bring potential clinical benefits to motor symptoms and quality of life [42,43]. Further, patients with PD suffer from the same health conditions (Heart Disease, Diabetes, Arthritis, etc.) as their age-matched counterparts and increasing physical activity has been shown to positively affect health outcomes in these individuals. Despite known benefits, it is estimated that 60% of PD patients perform minimal or no physical activity [12]. Barriers to exercise include concerns about obtaining minimal benefit, time constraints, and fear of falling [44], as well as lack of interest, poor health, weakness, pain, and inclement weather [45]. Primary care physicians are important partners in helping patients overcome these barriers by sharing knowledge and encouraging coordination of a goal-directed plan. While predictors of adherence to long-term exercising are largely intrinsic (self-motivation, social support, greater self-efficacy, and previous physical therapy) [46], primary care physicians can help by educating patients and families about the benefits of exercise and personalizing exercise plans for each patient. Physicians can refer patients to physical therapists, exercise specialists and relevant exercise programs in the area, research studies, local gyms, and senior centers for appropriate intervention or crafting of home exercise programs. To close this gap, clinicians can educate local centers on PD symptoms and, along with their patients, can interview provider to determine their professional experience with PD. One of the most critical roles of the primary care physician involves providing follow up to reassess exercise success.

In counseling with PD about exercise, it can be helpful to highlight the fact that many types of exercise improve outcomes in PD. With no one "best" approach identified to date, the range of helpful exercises provides patients with flexibility in choosing the approach that is most appealing. Patients should be encouraged to work with a physical therapist to determine which symptoms of the disease could be most effectively targeted and prioritized. By choosing approaches that are more individually desirable, patients may have increased motivation that can result in better long-term adherence. Regular and ongoing exercise may be more important than the individual details of the exercise itself. Many of the clinical benefits overlap between exercise types and studies demonstrated a movement back to baseline function once exercise was stopped [35].

Another important consideration in counseling patients with PD is that of safety. Given the morbidity associated with falls and fractures in PD, optimal exercise strategies will be approaches that are safe in a given scenario. Patients with substantial balance impairments, for example, should not perform exercises requiring balance without supervision and support. In such circumstances, balance exercises may be best completed within the context of supervised physical therapy or involve exercise not directly reliant on balance - such as using a recumbent bicycle.

Approaches to an exercise schedule can also be tailored to patient preferences. Social support is a known predictor of adherence and patients may benefit from partnering with spouses or friends to improve accountability. Attending exercise vetted classes for patients with PD - such as boxing with PD meetings or classes at senior centers - can improve adherence by adding a social element to the exercise. When feasible, trainers can provide individualized instruction and create a sense of obligation; some patients are more likely to exercise when they have made a financial investment. Still, for those who prefer to exercise independently, many of the exercises, such as tai chi or cycling, can be done at home.

As with any therapy - pharmacologic or non-pharmacologic – a successful treatment strategy requires commitment over the long term and reassessment over time. Each visit with a patient with PD should include a reassessment of compliance with an exercise regimen, apparent progress, as well as arising side effects, and whether adjustments in approach are needed.

Conclusion

Exercise in PD has been explored extensively in the past decade, with evidence suggesting that any and all types of exercise can provide short-term clinical and quality of life benefits. More research is needed to help understand if exercise programs provide generalized benefits or what strategies should be used to address particular deficits. Balance, flexibility, and stretching seem to improve motor symptoms and decrease falls, contributing to an improvement in overall function. Aerobic training appears to improve cognition, cardiovascular health, gait, and reaction time. Resistance training provides the strongest benefit in strength. Nontraditional exercise programs, including tango, tai chi, cycling, aquatic therapy, and boxing are potentially beneficial options for each patient.

Social interaction may play a role in the participants' interest and enjoyment of the training program. The physician will play a key role in optimizing the patient's other medical problems so that he or she can exercise optimally when faced with PD, and in creating an individualized exercise plan. Also, strategies to overcome barriers to exercise in PD need to be better addressed, perhaps beginning with the communication of care between primary care physicians, neurologists, physical therapists, and clinical exercise physiologists.

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