Rehabilitation Interventions in Parkinson Disease

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Objective: This self-directed learning module provides an evidence-based update of exercise-based rehabilitation interventions to treat Parkinson disease (PD). It is part of the study guide on stroke and neurodegenerative disorders in the Self-Directed Physiatric Education Program for practitioners and trainees in physical medicine and rehabilitation. This focused review emphasizes treatment of locomotion deficits, upper limb motor control deficits, and hypokinetic dysarthria. New dopaminergic agents and deep brain stimulation are facilitating longer periods of functional stability for patients with PD. Adjunctive exercise-based treatments can therefore be applied over longer periods of time to optimize function before inevitable decline from this neurodegenerative disease. As function deteriorates in patients with PD, the role of caregivers becomes more critical, thus training caregivers is of paramount importance to help maintain a safe environment and limit caregiver anxiety and depression. The overall goal of this article is to enhance the learner’s existing practice techniques used to treat PD through exercise-based intervention methods.

INTRODUCTION

Parkinson disease (PD) is a common aging-related neurodegenerative disease. Its cause is unknown; the pathophysiology has been explained by nigrostriatal pathway degeneration associated with excessive accumulation of alpha-synuclein in specific areas of the brain [1]. The vulnerable areas include the locus ceruleus, hypothalamus, cranial nerve motor nuclei and autonomic nervous system [1]. The mainstay of treatment is dopaminergic replacement or enhancement. Despite the new agents that are continually being developed to augment dopamine availability in neural tissue, as many as 50% of individuals with PD become refractory to medical management beyond 5 years after initiation of treatment [2]. This refractoriness is manifested as the patient experiencing rapid motor fluctuations and/or dyskinetic movements when on medication. Over the last 10 years, physiologic ablative procedures to effect “deep brain stimulation” of specific nuclei of the basal ganglia (subthalamic, globus pallidus internus) have become viewed as efficacious for up to 75% of appropriately selected individuals who are considered medically refractory. The procedures are considered palliative, and their efficacy has been defined by stabilized function and improved quality of life up to 5 years after surgery. For some individuals, this stabilization allows time to incorporate exercise-based interventions as an adjunct to medical and surgical treatments. These interventions can support functional stability before inevitable decline [3,4].

Several essential reviews of exercise-based interventions for persons with PD reported favorable outcomes [5-8]. However, the literature is still evolving in that: (1) less than half of the reviewed studies were randomized controlled trials; (2) about one-third of the reviewed studies had sample sizes of fewer than 16 subjects; (3) more than half of the reviewed studies discontinued their observations at the completion of the intervention phases, not observing whether the positive effects of various interventions were sustained over time. This present review provides an update of specific rehabilitation interventions in PD supported by the literature.

MULTIDISCIPLINARY REHABILITATION INTERVENTIONS

Sunvisson et al [9] reported their observations of treatment that combined nursing education and physical therapy (PT). In a case series of 43 subjects with PD, this program —
cues are hypothesized to be a way for the person with PD to use available neural networks that are mediated through the cerebellum as a therapeutic bypass strategy. Auditory cues, on the other hand, are hypothesized to be a therapeutic restorative strategy to replace externally the degenerated basal ganglia’s “internal timekeeping” function [18,19]. A series of studies [20-28] on the use of compensatory sensory systems to enhance mobility was explored in laboratory and clinical studies on gait. These studies compared outcomes during non-cued and cued conditions, often comparing the performances of subjects with PD and control subjects. The applied visual cues included floor stripes, timing lights and mirrors; the auditory cues included music and metronomes. Gait velocity and walking speed consistently, but not universally, improved during the cued conditions in those with PD. Visual cues more frequently led to increased stride length, while auditory cues were more frequently observed to increase cadence [20-28]. Visual cues were more effective at improving gait initiation than were auditory cues [29]. However, the only studies reporting that these positive effects of sensory cues on gait can be sustained over longer periods of time were case studies [30].

Dual task studies in which subjects performed cognitive or motor tasks while walking have been done [31]. In these “dual paradigm” studies the researchers’ intent was to “divide” the subjects’ attention between the tasks and the walking action. In these studies subjects performed concurrent tasks under cued gait training conditions. The findings from these studies indicate that external sensory cues fundamentally enhance attention to the alternative cue during ambulation. However, the hypothesis that giving one’s attention to external, rhythmic, auditory and visual cues will somehow either bypass or restore sensory control of movement is not supported [31]. Other investigators’ critiques of these sensory cueing studies reinforce that the fundamental deficit of gait problems in PD is attentional, and that any strategy that enhances attention during walking will have an effect similar to that of sensory cues [32].

Other approaches that use alternative sensory stimulation to influence motor control are less demanding of attentional resources. One randomized controlled crossover trial of whole-body-vibration in 68 subjects with PD demonstrated significant decline in clinical parkinsonian motor signs, particularly tremor and rigidity [33].

Traditional Physical Therapies (PTs)

Several clinical trials have applied a variety of exercise interventions, comparing treatment and no-treatment groups, in subjects with PD and control subjects. Intervention phases of treatment in these PT studies ranged from 1 to 20 weeks. When postintervention outcomes were observed, they were usually limited to less than 6 months after the end of the intervention phases. Outcome measurements included gait parameters, functional status and quality of life, and were generally reported as improved at the end of the intervention phases of treatment, but not consistently sustained thereafter.
Treatment of Freezing of Gait

Freezing of gait is reported to occur in up to 50% of individuals who have PD. It is associated with higher disease severity and longer disease progression [46]. Freezing of gait continues to be pathophysiologically elusive; however, it is well described clinically to occur when the sensory/perceptual demands of the environment require that a new motor program be used in order to continue a rational sequence of movement [47]. Demands that cause individuals to freeze include gait initiation, turning, walking through doorways, or approaching a terminal object. Freezing of gait can be minimized by using assistive devices, such as wheeled walkers, in combination with “sensory-motor tricks.” The devices provide consistent proprioceptive delivery and the “tricks” are actually behavioral strategies that can be taught to both patient and caregivers. One such strategy helps overcome the feeling that one’s feet are “glued” to the ground. The person with PD is taught not to actively disconnect his/her “glued feet” from the ground, but rather to allow the motor block to occur, momentarily relax, then re-initiate gait. During training, the person with PD is taught to use a hip/knee hyperflexion maneuver to step out and over an imagined or real visual cue. The cue may be, for example, a self-triggered laser beam at ankle level generated from the wheeled walker or cane or a low physical barrier, such as a yardstick laid flat on the floor [48,49]. Empirically, the presence of the sensory cue does not appear to be as essential as using the proximal leg flexors to re-initiate gait.

Treatment of Deficits in Postural Control and Balance

Several open clinical trials have focused on observing postural control and balance during and after exercise interventions [50-54]. The components of postural control and balance that were measured in these studies included axially-controlled movements, dynamic posturography, compensatory stepping in response to external provocations and ability to sustain tandem stance. The exercise interventions included upper and lower limb coordination and strengthening, spinal flexibility, postural correction, gait training, functional mobility training, external provocations on stable and unstable surfaces, and endurance training. All observed outcomes were improved immediately after the intervention phases of treatment, which ranged from 2 to 10 weeks [50-54], and up to 2 months thereafter [53,54]. Sensory cueing to enhance balance has not received as much investigation as gait in PD. One 3-week home-based program resulted in small but significant improvement in posture and timed performance during balance tests; however, functional improvements were marginal, and the therapeutic effects of cueing were not sustained 6 weeks later [55].

Complementary Exercise Treatments

Up to 40% of individuals who have PD use at least 1 type of complementary treatment (Table 1); vitamins and herbs, massage, and acupuncture are used most commonly. Twelve percent are reported to have used 5 or more of these therapies. These estimates are higher than what has been reported for the general American population (about 30%); their use is more common among those with PD who are younger at onset, have higher levels of income and education, and take a higher daily dose of dopamine equivalent [56]. Assessing efficacy of complementary exercise treatments to treat PD has received little rigorous study. The immediate improvements that were observed in 1 study after multi-modal “spa therapy” (thermal baths, drinking mineral water, relaxation and exercise therapies) were not sustained 6 months later [57]. Stalibrass et al [58] compared the Alexander technique, massage and no treatment during a nonblinded randomized clinical trial over 12 weeks. The Alexander technique was relatively

Table 1. Complementary Exercise Therapies and Their Use in Parkinson Disease

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<tr>
<th>Exercise</th>
<th>Definition</th>
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<tr>
<td>Alexander Technique</td>
<td>A method of becoming more aware of simple everyday movements that people of all ages and abilities can learn to relieve the pain and stress caused by everyday misuse of the body.</td>
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<tr>
<td>Tui-na</td>
<td>Chinese massage that uses kneading, pressing, rolling, shaking, and stretching of the body. Tui-na is thought to regulate qi (vital energy) and blood flow, and improve the function of tendons, bones, and joints.</td>
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<tr>
<td>Qigong</td>
<td>A form of traditional Chinese mind/body exercise and meditation that uses slow and precise body movements with controlled breathing and mental focusing to improve balance, flexibility, muscle strength, and overall health.</td>
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comparable to massage, and both were significantly better than no treatment at stabilizing activity level. The study subjects who were treated with the Alexander technique qualitatively reported more improvements in posture, balance, gait, speech, and sitting ability, while those who were treated with massage reported more often a relaxation effect and a “higher sense of well-being.” Svircev et al [59,60] compared neuromuscular massage and music relaxation therapy in a clinical trial that compared subjects with PD randomly assigned to each type of treatment. After twice weekly treatments over 4 weeks, significant improvements in clinical parkinsonian motor signs were observed in those who received massage. An open trial [61] investigating use of sequential tui-na massage, acupuncture, and qigong over 6 months in 25 subjects with PD found no objective improvement in measures of impairment and activity; however, subjective improvement was reported in 16 patients, and measures of quality of life and depression improved significantly. Burini et al [62] in a randomized controlled crossover trial comparing aerobic exercise and qigong in 26 subjects with advanced PD found that aerobic training, but not qigong, had significant impact on the ability of moderately disabled subjects to tolerate exercise. When exploring the use of exercise and chemical supplementation, Hass et al [63] randomized 20 patients with PD to receive progressive resistive training combined either with creatine monohydrate or placebo for 12 weeks. The former group demonstrated significantly greater improvements in strength, particularly as measured by their ability to arise from a chair.

**Treatment of Upper Limb Motor Control Deficits**

Murphy and Tickle-Degnen’s review [64] of 16 studies involving OT-related interventions directed toward small samples of individuals who had PD was guardedly optimistic regarding the outcomes after a variety of interventions. Several studies incorporated external cueing strategies. Platz et al [65] studied the speed and accuracy of performing an upper limb aiming task in bradykinetic-predominant individuals who had PD. The tasks were performed under 2 training conditions, aiming with and without an auditory cue. No differences in improvements of performance speed between the cued and uncued training conditions were observed. Rogers et al [66] applied a serial 2-way reaction time task in which advanced information (visual cue) about the next movement was not provided until after the current movement was initiated. Their objective, thus, was to probe the ability to use advanced information to guide movement. When using the sequential sensory cues became a more exact way to guide fine motor control, the subjects with PD displayed significantly slower movement compared to the control subjects. This finding suggests that attention to the cue alone may not be adequate, and that perhaps what was problematic in the subjects with PD was an inability to plan motorically when provided more specific sensory information. Meshack et al [67] studied the therapeutic use of weighted utensils and wrist cuffs as a compensatory strategy in tremor-predominant individuals with PD. No differences in modifying the amplitude or frequency of tremor were observed. Studying the effects of visually-guided virtual reality training in 2 persons with PD, Albani et al [68] observed their performance of 3 upper-limb functional activities: The use of virtual reality was viewed as successful; however, this success did not translate into improved function in everyday life.

**Treatment of Hypokinetic Dysarthria**

Critical reviews [69-71] of speech therapy interventions in PD have concluded that evidence exists to support their efficacy, but that evidence is equivocal. The best-studied exercise-based treatment for hypokinetic dysarthria is the Lee Silverman Voice Treatment (LSVT®) program, which has been reported as efficacious up to 24 months after treatment. This therapy has 3 aims: (1) to increase strength and muscle endurance of the respiratory muscles in order to overcome rigid laryngeal muscles that create resistance to airflow and hypophonia; (2) to facilitate more complete vocal cord adduction by increasing subglottal air pressure and vocal cord vibration; and (3) to “recalibrate” the impaired sensory perception of the effort to speak that prevents accurate self-monitoring of vocal output [72-77]. It also has 3 caveats: it should be administered by a speech and language pathologist trained in LSVT; it requires a commitment to intensive treatment for 50 minutes, 4 times weekly within a 1-month time period; and it requires participation in daily “homework” during treatment and thereafter to maintain the observed gains from treatment. When directly compared to therapy aimed only at enhancing vocal volume by facilitating increased respiratory effort, LSVT is superior because it both enhances vocal volume and facilitates vocal cord adduction [73,74]. LSVT also has “generalizability” of observed improvements beyond vocal volume to include prosody, intelligibility, facial expression and swallowing [72,73,75]. Liotti et al [76] reported changes in the brain, as seen in positron emission tomography (PET) in 5 subjects with PD who had been treated with LSVT. There was “normalization,” or decreased cerebral activation, in the left motor cortex and concurrently increased activation in the right anterior insular and dorsolateral prefrontal cortices and in the head of the caudate and putamen of the basal ganglia.

Other treatments that incorporate some or all of the components of LSVT, such as Pitch Limiting Voice Treatment (PLVT), have been promoted. This treatment, characterized as “speak loud and low” treatment was developed because LSVT (“think loud, think shout”) may be too effortful, resulting in highly pitched, strained, “screaming” vocal output. The deSwart et al [78] researchers reported that PLVT has comparable efficacy to LSVT, yet has the advantage of producing less pressured speech at more normal vocal frequencies [78].


**CAREGIVER TRAINING**

As the PD progresses, the increasing severity of cognitive impairments appears fundamental to increasing the burden of care [79]. The survey by Davey et al [80] of spousal caregivers of recurrent fallers who had PD found that caregivers may have their own “fear of falling” syndrome regarding their vulnerable spouses, and they often injured themselves when helping their spouses arise from the floor. These caregivers reported a lack of education about preventing falls. They also were not knowledgeable about how to manage the consequences of falls, such as minimizing potential injury to themselves and their spouse as they assisted the faller back to the upright position. Fernandez et al [81] explored the factors that underpin depression among spousal caregivers of those with PD; longer disease duration was the strongest predictor of caregiver depression.

Nursing researchers have investigated strategies that focus mainly on cognitive-behavioral approaches aimed at countering caregiver depression. These approaches include “learning” optimism; re-engaging with one’s “inner locus of control” to counteract a sense of being controlled by “outer forces;” maintaining one’s own life; encouraging the patient-caregiver dyad to stay active; and focusing on what is meaningful to the individual despite ongoing loss and frustration in handling loss as the disease progresses [82-84]. Interventions facilitating participation in the caregiver role (for example, appropriate biomechanical methods to provide mobility assistance) have not been studied. Nor have studies been done on therapies aiming to reduce the risks of caregiver “strain” in PD. This line of investigation has been explored in patient-caregiver pairs among populations with Alzheimer disease. For example, the OT-based caregiver training program of environmental skills building presented by Gitlin et al [85] can serve as a model for caregiver training in PD.

In summary, new dopaminergic agents and deep brain stimulation procedures are facilitating a longer period of functional stability for individuals who have PD. Adjunctive exercise-based treatments, thus, can be applied over longer periods of time to optimize function before inevitable decline from this neurodegenerative disease. Strong evidence exists that external sensory cues are useful in the treatment of locomotion deficits, including freezing of gait. Gait parameters, functional status and quality of life generally improve at the end of treatment, but are not consistently sustained thereafter. There is also strong evidence that targeted exercise produces short-term improvement in postural control and balance. While complementary treatment modalities are used widely by patients with PD, only use of various massage techniques seems to improve subjective well being and quality of life. Interventions based on occupational therapy techniques that use external cueing and are aimed at treating upper limb motor control deficits have some efficacy. Use of weighted utensils and visually based virtual reality does not seem to affect tremor or function, respectively. Some evidence exists that techniques such as LSVT and PLVT are superior to speech therapy for treatment of hypokinetic dysthria, since speech therapy only aims at a single factor, that of enhancing vocal volume by facilitating increased respiratory effort. Caregiver education may provide caregivers with a greater sense of control and mitigate their depression. It is not clear whether interventions can increase caregiver participation or reduce caregiver strain. Physiatrists must be familiar with the available modalities and the body of evidence supporting the use of specific treatment approaches, while balancing the ever incomplete data against the particular needs of individual patients.

**REFERENCES**


* Indicates key references.