The Impact of Exercise Rehabilitation and Physical Activity on the Management of Parkinson’s Disease

A.M. Johnson, PhD, Assistant Professor, Faculty of Health Sciences, University of Western Ontario, London, ON.

Q.J. Almeida, PhD, Director, Movement Disorders Research & Rehabilitation Centre, Wilfrid Laurier University, Waterloo, ON.

Introduction

Parkinson’s disease (PD) is the most common form of parkinsonism, constituting almost 80% of all parkinsonism. It is produced by lesions in the basal ganglia, particularly in the substantia nigra, that result in marked dopamine depletion. The predominant strategy for medical management of the symptoms of PD is levodopa therapy (with either levodopa-replacement medications or dopamine agonists), and most symptoms are highly responsive to this treatment. It is well-established, however, that both longevity (i.e., the duration of “on” periods) and overall effectiveness (i.e., the quality of improvement demonstrated during these “on” periods) diminish with chronic levodopa usage. Furthermore, long-term utilization of levodopa may lead to an increased risk of dyskinesia, in which the patient engages in involuntary writhing movements during “on” periods. While it is unlikely that physical or cognitive treatment strategies will supplant pharmacological treatments, many such techniques have been demonstrated to show incremental improvement when combined with levodopa therapy. Furthermore, recent animal studies have suggested that exercise rehabilitation may stimulate the production of brain-derived neurotrophic factors, normalize dopamine production, and protect the nigrostriatal neurons that usually deteriorate in PD. It is plausible, therefore, that effective nonpharmacological treatment strategies might lead to lower therapeutic levels of dopaminergic medications for some patients, thereby improving the long-term prognosis.

The notion of treating the overt motor symptoms of PD through physical interventions is not new. Despite the fact that PD is a neurological disorder, many of its primary physical symptoms (bradykinesia, postural instability, and rigidity) are motor sequelae that are frequently found among otherwise healthy older adults. Accordingly, rehabilitation has traditionally focused on musculoskeletal strategies that have been successful in other (non-PD) populations. However, more recent research has focused on the development of therapies that leverage motor control hypotheses of PD, employing more of a “neurological” approach to treating motor symptoms. While both strategies have demonstrated some benefit in patient populations, taken as a whole, the literature suggests that combined approaches obtain the greatest success.

Musculoskeletal Rehabilitation Strategies

The most frequently targeted symptoms of PD (in both musculoskeletal and neurological rehabilitation paradigms) are gait dysfunction and postural instability—perhaps because these rehabilitation strategies have proven less effective, thus far, for tremor and bradykinesia. To this end, physical therapy programs typically...
emphasize strength training (predominantly trunk strength but also for all four limbs), balance training, and a range of techniques aimed at improving flexibility. Furthermore, the most effective therapeutic programs involve repetitive exercises that can be practised by patients at home. de Goede et al.\textsuperscript{11} conducted a meta-analysis of physical therapy interventions among patients with PD and found that conventional musculoskeletal therapy had a significant effect on (in order of descending effect size) walking speed, stride length, activities of daily living, and neurological signs.

Improving trunk strength, in particular, has numerous implications for individuals with PD and trunk strength in individuals with PD have been demonstrated to produce significant improvements in weakness and stiffness that are similar to improvements demonstrated by healthy older adults. Similarly, exercises that focus on improving mobility of the trunk have been demonstrated to produce a significantly improved ability to recover from postural disturbances.\textsuperscript{13,14}
Another key rehabilitation technique that has met with success is bodyweight-supported treadmill training (Figure 1). In this technique, patients are harnessed within an overhead sling that supports a portion of their weight while they walk on a treadmill. The technique is intended to allow patients an opportunity to walk at an increased rate (and for a longer distance) than would otherwise be possible. This simple physical training method has been shown to produce greater gait improvements than conventional physical therapy approaches, with effects lasting for at least 4 months after the conclusion of therapy. Interestingly, studies that compare actual gait practice and training (where the patient walks) have shown a significant benefit over the training of individual components of gait (i.e., gait preparation exercises). Future research in this area needs to investigate whether improvements elicited by treadmill training are attributable to increased safety and security (which may improve compliance with prolonged physical activity), increased feelings of self-efficacy, or improved motor programming.

**Neurological Rehabilitation Strategies**

The most interesting advances in PD rehabilitation are being made within neurological paradigms. Therapeutic techniques that leverage this perspective are attempting either to create new pathways within the brain or to help patients create a cognitive overlay for the defective programs that are currently in use. These techniques focus on the development of new movement strategies.

Parkinson’s disease gait research typically focuses on self-paced walking tasks and the differences between patients with PD when they are “on” and “off” their dopaminergic medications. These studies suggest that spatial impairments (e.g., decreased stride length) but not temporal characteristics (e.g., stride cadence) improve with dopaminergic treatment. Therefore, one of the most promising avenues of neurological rehabilitation research involves the use of sensory enhancement to cue movement—both during gait training and in community ambulation. Both visual and auditory cues have been used successfully to produce significant changes among patients with PD. For example, visual step cueing (patients are instructed to step toward parallel lines placed on the walking surface) have been demonstrated to improve the shuffling gait typical of patients with PD, with improvements persisting when patients are in an “off” period (with respect to their dopaminergic medications). In one interesting study, Dam et al. compared conventional physical therapy with “sensory-enhanced physical therapy.” Both visual (in this case, footprints on which the patient walked during gait training) and auditory cues (alternating high and low tones during gait training to innervate leg lifts and drops, respectively) were added to the training program. While both conventional and sensory-enhanced therapy produced significant changes, sensory-enhanced therapy produced changes (improved gait velocity, stride length, and step cadence) that were maintained at 12 months, while the effects of conventional therapy were lost by 4 months. Outside the laboratory, patients report success with the use of visual cues (e.g., stepping over an inverted walking stick, or stepping toward a dot made on pavement with a laser pointer) to overcome “freezing” (a sudden absence of voluntary gait). Rhythmic auditory stimulation (e.g., listening to marching music) can also be used improve gait cadence during activities of everyday living.

**The Importance of Physical Activity**

The message that is reiterated most frequently is that any positive effects of physical rehabilitation are transient without the maintenance of physical activity or (ideally) ongoing physical therapy. Additionally, at least one large epidemiological study has demonstrated that physically active patients had a lower mortality rate, better quality of life, and increased function in activities of daily living than did less active individuals with PD (despite control of age, sex, and disease duration). Unfortunately, convincing individuals with PD to engage in reasonable, safe physical activity is often difficult. For some individuals with PD, intense physical activity results in a qualitative reduction in the duration of medication effect due to the fact that many people with PD absorb levodopa more slowly and less completely when exercise is started at the time of or just before levodopa ingestion. Furthermore, some individuals with PD avoid physical activity due to concerns over their symptoms; for example, those with reduced endurance and impaired gait parameters are hesitant to hike, those with reduced reaction time and range of motion are reluctant to engage in racquet sports, and those with an overall increased fatigue tend to avoid physical activity across the broader spectrum. From a physiological perspective, individuals with mild to moderate PD have a largely normal exercise capacity, demonstrating nonsignificant peak oxygen consumption and peak workloads when compared with healthy controls, provided that periods of exercise are of short duration and provide frequent intervals for rest. Furthermore, medication absorption and effectiveness are not significantly affected by normal exercise, provided that acute exercise is not started for a period of 1 hour after levodopa ingestion.

Sunvisson et al. suggest that gait rehabilitation can be as simple as increased walking. In a small sample of Swedish patients, 1 week of daily 4 km walks produced significant improvements in movement time, as measured using computer-controlled opto-electronic cameras. Despite the fact that this experimental group was highly self-selected, participants demonstrated a significant incremental effect over conventional physical therapy and pharmacological therapy, with effects lasting for approximately 4 months after treatment.

**Conclusion**

It is unlikely that nonpharmacological treatments will supplant levodopa therapy. In fact, no research has ever
investigated the impact of physical rehabilitation in the absence of drug treatment, nor is such research likely to be conducted, given the ethical concerns surrounding standards of care. Taken together, however, the issues discussed above suggest that significant work remains to be done to identify mechanisms for improving symptoms of PD through nonpharmacological means and to identify methods through which individuals with PD might be encouraged to initiate and maintain physical activity.

No competing financial interests declared.

References