**Background Information**

Parkinson’s disease (PD) is a neurodegenerative disorder that is often characterized by motor system changes that result in the “typical” signs of PD: resting tremors, rigidity, bradykinesia, and gait dysfunction. While these motor impairments alter an individual’s functional abilities, cognitive dysfunction has a significant influence as well. Physical therapists need to understand the various factors that may impact mobility and progress with our patients diagnosed with PD.

The purpose of this literature review is to understand why and how executive dysfunction manifests in people with PD, identify evidence based interventions that may reduce these cognitive impairments or secondary impairments, and discuss the implications of the results on physical therapy practice.

**Executive Function**

Before explaining how PD impacts executive function, we must understand what executive function is. While there is no established definition for executive dysfunction1, Cicerone et al2 stated executive function consists of four domains, including: executive cognitive functions, behavioral self-regulatory functions, activation regulating functions, and metacognitive processes. Cicerone et al2 then described that metacognitive processes includes personality, social cognition, autonoetic consciousness, and self-awareness. Although there are variable opinions as to defining executive function, simply recognizing the multitude of processes that potentially fall under the umbrella term of executive function will enable us to better appreciate the many types of executive dysfunction in people with PD. For the purpose of this paper, Cicerone et al2’s explanation of executive function will be used.

**Executive Function and PD**

Pathophysiology

PD is characterized by the degeneration of the substantia nigra, which results in the reduction of dopamine in the basal ganglia.3 Dirnberger and Jahanshahi4 explain the posterior putamen is associated with one’s ability to execute automatic behaviors. Therefore, with PD affecting the putamen, individuals require additional “cortical executive control” to compensate during what would typically be an automatic task.4 By compensating with “cortical executive control”, the central executive processes are excessively challenged.4

Clinical Presentation

Executive dysfunction is one of the first cognitive symptoms noted in the early stages of PD.4,5 PD most commonly impacts three of the four domains discussed by Cicerone et al2: executive cognitive functions, metacognitive processes, and activation regulating functions.

*Executive Cognitive Functions2*

Dirnberger and Jahanshahi4 state the most common executive cognitive functions impaired secondary to PD include: internal control of attention, set shifting, planning, inhibitory control and conflict resolution, dual task performance, decision making, and social cognition and theory of mind. Trouble with these various abilities can impact both the physical therapy session along with an individual’s functioning in every day life. For example, challenges with internal control of attention may support the idea of providing external cues in the clinic if the individual cannot shift their attention to different parts of a certain task. Also, difficulties with set shifting may present clinically as the patient may not be able to quickly change their focus working on one activity during physical therapy to the next. Challenges with dual task performance are discussed later in this paper.

*Metacognitive Processes2*

# Difficulties with regard to self-awareness have been identified in patients with PD.1,4,6 Researchers noted people with PD incorrectly rated their performance after completing two different standardized measures used to assess executive cognitive function.1 These results indicate patients may not understand their executive function deficits. Additionally, other researchers identified reduced self-awareness during the performance of motor tasks. Participants were asked to evaluate their performance after sitting on a chair, tapping their finger, forearm pronation and supination, transferring from sit to stand, ambulating, and speaking.6 Evaluators’ and participants’ scores were compared in regards to recognizing signs of tremor, dyskinesias, altered speed or size of the movements, trouble balancing, shuffling gait, reduced arm swing, etc. 6 In addition to findings of reduced self-awareness, the researchers identified a statistically significant correlation between impaired self-awareness and postural instability and gait difficulty. 6 Reduced self-awareness is especially important considering the safety for individuals with PD as well as recognizing and understanding errors made during physical therapy sessions.

*Activation Regulating Functions2*

# Apathy is another common symptom in individuals with PD.4 Interestingly enough, researchers have identified apathy is correlated with postural instability.7 In this study, participants simply stood for 20s in three separate testing sessions with their feet in a comfortable position.7 Their sway was recorded and ultimately led to the calculation of postural instability during static standing.7 It is noteworthy that there could be a potential relationship between the behavioral and motor aspects for someone with PD.

# Impact on Functional Abilities

Common issues we see when working with patients with PD include gait dysfunction, postural instability, and difficulty performing dual-tasks. While we are witnessing motor abilities, cognitive processes are often underlying the actual performance of these tasks.4,8,9

Freezing of gait (FOG) is a common gait impairment in individuals with PD. Researchers agree motor, cognitive, and affective factors all can influence FOG.4,8Nieuwboer9 discussed four theories of FOG.  (1) The threshold model- too many motor deficits and get motor breakdown.9 (2) The interference model- too difficult for locomotion when addressing cognitive, limbic and/or motor input.9 (3) The cognitive model- unable to process response conflict so they end up with behavioral indecision.9  (4) Decoupling model- disconnect between preparatory programming and intended motor response so the automatic movement doesn’t occur.9  While these theories do not include every reason for FOG, we can appreciate how executive function ties into FOG.

Another research area of interest is the performance of dual task activities and PD. Researchers have identified dual task deficits related to postural control, speaking, upper extremity tasks, and during gait.10 Gait impairments during dual-task activities (whether the second task is motor or cognitive) include decreased gait speed, stride length, and gait asymmetries. These gait impairments are found in addition to single task gait dysfunction identified in people with PD, which also include reduced gait speed, stride length, and gait asymmetries.10 Therapists should remember to identify and address gait impairments during both single and dual task scenarios. Additionally, therapists should consider other dual task scenarios that may not involve gait, but could lead to reduced performance or safety secondary to divided attention.

Interventions

 Various researchers have studied interventions in an attempt to either directly improve the primary impairment (i.e. cognitive dysfunction) or to identify compensatory strategies that will improve the secondary impairments (e.g. dual task performance deficits).

Cruise et al11 identified an exercise program significantly improved executive cognitive function in individuals with PD. The exercise program consisted of aerobic and strength training for one hour, two times per week, for a total of 12 weeks. Tanaka et al12 confirmed the benefits of aerobic training, supplemented by balance, strengthening, coordination, and flexibility exercises, on executive cognitive function. Participants performed these exercises for one hour, three times per week, for 6 months. Ridgel et al13 also measured improved executive cognitive functioning after individuals participated in a passive lower extremity cycling program for 30 minutes one time per week, for three weeks. Milman et al14 conducted an interesting study evaluating the influence of cognitive rehabilitation, in the form of a video game, on executive function and mobility. The participants sat and “played” the video game for 30 minutes, three days per week, for twelve weeks. The participants demonstrated improved executive cognitive functioning and TUG scores.14

 Evidence suggests visual and auditory cues may improve various gait measures during dual task activities. Rochester et al15 studied the influence of auditory cues for individuals with PD who have moderate cognitive impairments as measured by the Mini Mental State Examination (MMSE). The participants had mild to moderate FOG. The auditory cue was a metronome along with verbal commands relating to taking a step to the beat. The auditory cues significantly reduced dual task deficits by increased gait speed and stride length compared to the group that did not receive cues. Mak et al16 confirmed the combination of auditory and visual cues improve gait speed, stride length, and cadence by using stoplights and an auditory beep.

Kegelmeyer et al17 compared various assistive devices to identify if one assistive device may provide optimal safety and gait performance compared to others. Kegelmeyer et al17 identified the four wheeled walker as the optimal choice considering safety and decreased gait variability compared to the other devices. Interesting to note, though, patients demonstrated FOG with the use of all assistive devices.17 The U step walker and four wheeled walker had the least number of FOG episodes.17 Donovan et al18 studied the impact of a laserlight attached to a cane or walker and FOG. Participant reports of FOG significantly improved, along with significant improvements in the number of falls. Gait speed, however, did not significantly improve. Bunting-Perry et al19 found opposing results in their study of the influence of laserlight and FOG. The laserlight did not significantly improve the incidence of FOG.

Implications for Physical Therapy

Learning to understand and recognize the various processes impacted by executive dysfunction will enable us to provide a more appropriate POC. Requiring a standardized test to assess an individual’s executive cognitive function (e.g. MoCA) is not indicated for a physical therapist at this time. A functional goal in physical therapy would not be to improve the patient’s executive function directly. It is more appropriate to recognize executive dysfunction, and identify its impact on the patient’s performance and daily functions.

By recognizing executive dysfunction we may identify the need for additional team members to ensure we address the potentially comprehensive impact of the impaired processes. We might consider referring the individual to a neuropsychologist in hopes of cognitive rehabilitation positively impacting their motor abilities. Other team members may aid in addressing other daily challenges due to executive dysfunction.

Physical therapists should understand the complex interplay between motor and cognitive processes so that we try utilizing evidence based interventions to improve the secondary impairments from cognitive dysfunction.

Overall, there is strong evidence for the use of external cueing to reduce the impact of executive dysfunction on dual-task activities and FOG. We should consider which type(s) of cueing are best for the patient, and which types may lead to continued performance once cues are removed. The four wheeled walker or U step walker may be a more appropriate assistive device for individuals with PD presenting with FOG. Evidence is mixed regarding the use of a laserlight attachment to an assistive device at this time. As always, clinical decisions should consider not only evidence but also patient preferences and clinical experience.

Conclusions

Executive function is an umbrella term for various important processes. Deficits in executive function may influence the daily life and functional abilities of an individual with PD. Physical therapists should stay current on research related to the potential clinical presentation and impact of executive dysfunction. Additionally, physical therapists should be aware of potential interventions that may either directly improve executive dysfunction or may compensate for impairments secondary to executive dysfunction to promote overall well-being.

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