

Executive dysfunction is a cognitive impairment that affects individuals with Parkinson Disease (PD). Executive function deficits are characterized by the inability to plan and initiate a task, reduced problem-solving skills, and impaired ability to perform goal-driven behavior.¹ The literature indicates that approximately 30% of PD patients demonstrate executive function impairments, which affects an individual's ability to perform tasks independently.² Understanding the causes of executive dysfunction in the PD population can help physical therapists implement evidence-based treatments, in conjunction with other medical interventions, to best facilitate independent completion of functional tasks.

Individuals with PD are susceptible to executive function impairments due to the damage to the dopaminergic neurons in the brain.³ Dopamine is a neurotransmitter that is essential to normal executive functioning because it helps mediate signals from the frontal lobe regarding planning and tasks performance.⁴ In patients with PD, however, dopaminergic neurons in the brain are damaged, resulting in a reduction in the amount of dopamine in the brain.³ The dopamine deficiency in the brain has a profound impact on both motor and cognitive functioning for patients with PD. Although executive dysfunction may be apparent in the early stages of PD, this cognitive deficit is often overlooked due to prominent motor changes, such as rigidity and tremors.⁵ Given the prevalence executive function impairments, however, proper assessment of both cognition and motor skills should be performed following a diagnosis of PD.

Although there is much research available regarding the motor deficits of PD, the exact pathophysiology of cognitive impairments in PD remain elusive. There are many theories that seek to explain the direct cause of executive function impairments for this patient population. In general, the literature identifies dopamine depletion as the underlying cause of cognitive and motor impairments in this patient population.⁵ According to the

literature, involvement of both the nigrostriatal and mesocortical pathways has been linked to executive function impairments in patients with PD.⁵ The mesocortical pathway relays information from the dorsolateral prefrontal cortex to the ventral tegmental area, while the nigrostriatal pathway relays information from the substantia nigra to the caudate and putamen.^{3,6} With disruption of these critical pathways, the basal ganglia and other modulators of cognition are unable to inform and mediate executive functioning.⁶ Since PD is a progressive disease, the deterioration of dopaminergic neurons progresses over time.³ As a result, the presentation of executive dysfunction may worsen with disease progression.³ In addition, research indicates that other neurotransmitters, such as acetylcholine, may also contribute to cognitive impairments in PD.⁵ Overall, the reduced level of dopamine in the brain of patients with PD is the underlying cause of both motor impairments and executive dysfunction.

Executive function impairments in PD patients manifest in many ways, all of which may affect an individual's functional capacity and independence. First, executive dysfunction can present in PD patients via reduced attention.³ Specifically, individuals with PD may have difficulty maintaining attention to a task when there is no external cue to redirect focus on the task.³ This manifestation of executive dysfunction is known as impaired "internal attention control," since the patient does not have the internal cues required to attend to a task.³ Another manifestation of executive dysfunction in PD is impaired planning. This refers to one's ability to establish the appropriate sequencing required to perform a task.³ According to the literature, PD patients with executive function impairments are likely to require verbal cues regarding sequencing in order to initiate and complete a goal-oriented task.³ Another sign of executive function impairment for PD patients is deficits in set shifting, or easily transitioning between tasks.^{3,6} Set shifting is considered a complex skill that requires an individual to monitor and respond to both

internal and external feedback.⁶ Patients will be unable to switch between tasks, which must be taken into account when planning therapy sessions. Set shifting difficulty is likely one of the first executive function impairments evident for patients with PD.³ Working memory impairment is another manifestation of executive dysfunction in PD patients.⁶ Patients with impaired working memory present with difficulty in storing information in the short-term, which impacts learning a new skill or re-learning a skill.¹ Decline of spatial working memory occurs rapidly in patients with PD and is likely to be more severe than other working memory deficits.³ Finally, patients with impaired executive function will likely have difficulty with problem-solving strategies and correction of errors.⁶ Even if a patient is able to detect an error in the performance of a task, he or she will require extra time or verbal assistance to correct the error.³ These many manifestations of executive function impairments depend on individual factors, such as patient's disease stage, age, and prior functioning.

Given the pathophysiology of executive dysfunction in PD, much research has been devoted to using dopamine-enhancing medications to reduce the cognitive impairments associated with the disease. However, these drugs do not *always* have a positive effect on cognitive impairments.³ Specifically, various dopamine receptors targeted by the drugs have differing effects on executive functioning. For example, some medications used to treat executive dysfunction demonstrate no negative side effects for cognition, while use of other drugs resulted in impaired working and verbal memory.³ Although there is promising research, there is currently no pharmaceutical intervention that effectively eradicates executive function deficits in PD patients.

In addition to pharmaceutical management of executive function impairments, there is research that demonstrates positive outcomes following specific cognitive training. For example, one study compared the effects of intensive executive function training with traditional therapies, such as occupational and physical therapy.⁷ Authors of this study

indicate that PD patients who received the executive function training demonstrate improved working memory and executive functioning, as indicated by better performance on outcome measures.⁷ Other researchers studied the use of computer-based, specialized training to improve initiation of movement.⁸ Although PD patients continued to demonstrate deficits compared to participants without PD, the computerized intervention resulted in improved initiation of complex movement.⁸ There is new research available that indicates cognitive rehabilitation therapy specific to executive dysfunction may be use in treating PD patients.⁹ These specific, repetitive interventions indicate that interventions tailored to patients' executive function deficits may be beneficial interventions for patients with PD.

With regard to physical therapy interventions, there are treatment approaches designed for use with patients who present with executive function impairments. Although these approaches do not describe specific interventions, a therapist may apply the theoretic construct to this patient population to effectively minimize the influence of executive dysfunction.⁹ One such strategy is the compensatory approach to treatment. In this treatment style, the therapist reduces the influences of executive dysfunction.⁹ By performing the given therapeutic task in a quiet room, for example, the therapist can improve attention to task performance. The restorative approach is another strategy that is used for patients who demonstrate executive dysfunction.⁹ This approach is designed to help improve performance of specific activities of daily living (ADLs) by requiring repetition of specific tasks.⁹ This approach aims to reduce working memory impairment in patients with executive function impairments, but little research is available regarding the specific PD subpopulation. Due to the progressive nature of PD, it is important to remember that no treatment will eliminate the presence of executive dysfunction secondary to dopamine deficiency.³ However, the theories described above can be applied to maximize a patient's maintenance of functional independence.

Interventions selected to address executive function impairments in PD patients have various mechanisms that may facilitate independence. The pharmaceutical interventions seek to address the chemical changes that occur during PD, causing executive function impairments.⁶ Specifically, dopamine therapies aim to replace the dopamine neurotransmitter in an effort to offset the dopamine deficiency.^{3,5} This direct mechanism of intervention can be beneficial, but the effects of other neurotransmitters on cognitive function likely reduce the success of medication interventions.^{3,5} Therefore, other interventions that seek to address the manifestations of executive dysfunction in PD patients must be utilized.

The non-pharmacologic interventions and theories described are successful in treatment of the PD population because they adapt motor learning styles to suit patients with executive dysfunction. For example, in the executive function rehabilitation research described above, patients performed one specific task repeatedly without interruption.^{7,8} Patients' potential to succeed in these studies was maximized by reducing the possible attention deficits and set shifting.³ The mechanism, therefore, is the use of blocked practice. Another mechanism of the cognitive training is specificity of training.^{7,8} In requiring specific task performance, the training reduces the challenge of transferring learned skills. In this mechanism, the therapist can avoid the influence of working memory impairments, which could affect a patient's ability to transfer a skill.¹ Finally, the mechanism in the compensatory approach is problem-solving strategies in order to ensure that the performance of ADLs and self-care remains feasible.⁹ The compensatory approach must incorporate patient and family education, which will help to enhance compliance of this approach at home. The mechanisms behind the treatment strategies for executive dysfunction in PD cannot facilitate improvement due to the progression nature of PD.⁶ The

therapist can, however, modify motor learning principles in order to improve the patient's capacity for independence, despite executive function impairments.

In learning more about executive function impairment in PD, I gained insight into the relationship between motor and cognitive impairments in this patient population. As a future physical therapist, I am eager to address the motor deficits that present in the PD population. The research, however, demonstrates that executive function impairments must be considered in treatment. Furthermore, I learned that treatment of a patient with executive dysfunction requires immense planning before a treatment session. In the future, I plan to adjust my intervention strategies for this patient in order to minimize potential sources of distraction and changing task. One specific aspect of executive function impairment of which I was unaware is set shifting impairment.³ In a typical treatment, I like to be flexible with interventions and utilize different exercises. With this impairment, however, it is important to remain patient during a given task. Although I might be tempted to switch out the intervention, this could cause additional confusion and frustration for the patient.³ In addition, changing the task too quickly could result in poor motor performance.

Executive function impairments can significantly impact a patient's course of treatment in physical therapy. Although motor impairments are the external cardinal signs of PD, it is essential to consider the cognitive effects of the disease in treatment goals, plan of care, and intervention selection. The various manifestations of executive dysfunction may exacerbate the presence of the motor impairments for PD, which can cause frustration for both the patient and the practitioner. Providing an environment in which the patient can succeed is fundamental in understanding the effects of executive function impairments.

Resources

1. McKinlay A, Grace RC, Dalrymple-Alford JC, Roger D. Characteristics of executive function impairment in Parkinson's disease patients without dementia. *J Int Neuropsychol Soc.* 2010;16(2):268-277.
2. Parker KL, Lamichhane D, Caetano MS, Narayanan NS. Executive dysfunction in Parkinson's disease and timing deficits. *Front Integr Neurosci.* 2013;7:75.
3. Dirnberger G, Jahanshahi M. Executive dysfunction in Parkinson's disease: A review. *J Neuropsychol.* 2013;7(2):193-224.
4. Yogev-Seligmann G, Hausdorff JM, Giladi N. The role of executive function and attention in gait. *Mov Disord.* 2008;23(3):329-342.
5. Rodriguez-Oroz MC, Jahanshahi M, Krack P, et al. Initial clinical manifestations of Parkinson's disease: features and pathophysiological mechanisms. *Lancet Neurol.* 2009;8(12):1128-1139.
6. Zgaljardic DJ, Borod JC, Foldi NS, Mattis P. A review of the cognitive and behavioral sequelae of Parkinson's disease: relationship to frontostriatal circuitry. *Cogn Behav Neurol.* 2003;16(4):193-210.
7. Sammer G, Reuter I, Hullmann K, Kaps M, Vaitl D. Training of executive functions in Parkinson's disease. *J Neurol Sci.* 2006;248(1-2):115-119.
8. Disbrow EA, Russo KA, Higginson CI, et al. Efficacy of tailored computer-based neurorehabilitation for improvement of movement initiation in Parkinson's disease. *Brain Res.* 2012;1452:151-164.
9. Calleo J, Burrows C, Levin H, Marsh L, Lai E, York MK. Cognitive rehabilitation for executive dysfunction in Parkinson's disease: Application and current directions. *Parkinsons Dis.* 2012.