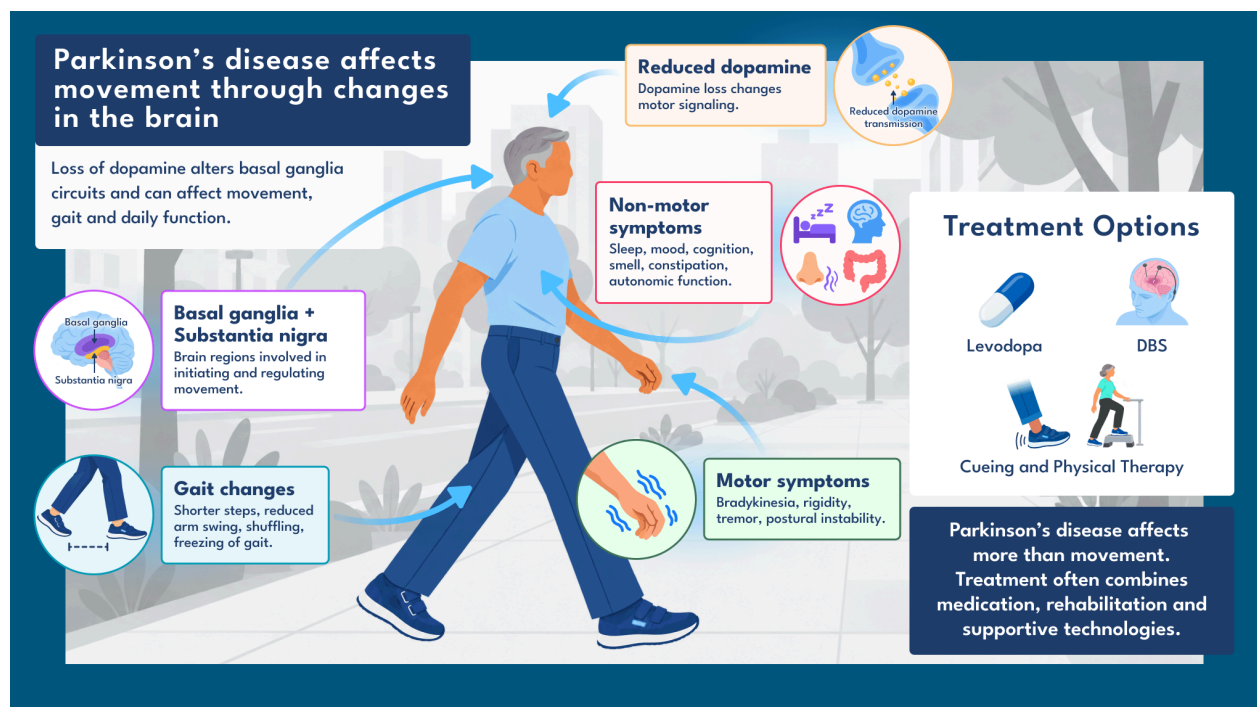


Parkinson's Disease: Understanding Symptoms, Movement, and Treatment

Executive Summary

Parkinson's disease is a progressive neurological disorder that affects movement and many non-motor functions. A central feature of the disease is the gradual loss of dopamine-producing neurons, which disrupts communication within the brain networks responsible for controlling movement.

Treatment typically involves a combination of medication, advanced therapies such as deep brain stimulation, exercise, and physical therapy. Rehabilitation can address changes in strength, balance, walking, and movement amplitude. External cueing provides additional visual, auditory, or tactile information to support movement. Newer wearable technologies are exploring ways to deliver these cues during everyday walking and adapt them to the individual.



1. Movement Begins in the Nervous System

How different parts of the nervous system work together to make movement possible.

Every movement we make depends on the coordinated activity of the nervous system. Whether we are reaching for a cup, standing up from a chair, or taking a step forward, different areas of the brain and spinal cord work together to plan, initiate, coordinate, and adapt movement [1].

Movement is not controlled by a single area of the brain. The cerebral cortex plays a role in planning and producing voluntary movement, while the brainstem and spinal cord organize posture, muscle activity, and motor signals throughout the body [1].

Another group of structures, collectively known as the basal ganglia, helps regulate voluntary movement by interacting with the cerebral cortex and other brain regions [2]. These structures are particularly important in Parkinson's disease because their activity is strongly influenced by dopamine [2,3].

2. How the Brain Regulates Movement

How interconnected brain regions help initiate, coordinate, and adjust our movements.

The basal ganglia are part of a network that regulates the initiation and performance of movements. Rather than directly activating individual muscles, these structures interact with the cerebral cortex, thalamus, and other regions involved in movement control [2–4].

Communication within these circuits depends partly on dopamine. Dopamine-producing neurons in a small region of the brain called the substantia nigra send signals to the striatum, an important part of the basal ganglia. Dopamine modulates these circuits, contributing to the initiation and scaling of movement [2–4].

This regulation allows movements to be appropriately timed and sized. For example, taking a step requires not only moving the leg forward, but also regulating the size and timing of the step, as well as posture and the transition into the next step.

In Parkinson's disease, dopamine-producing neurons progressively degenerate. As dopamine becomes less available, communication within these motor networks changes [3].

3. When Dopamine Becomes Less Available

How changes in dopamine alter the neural circuits that help regulate movement.

The reduction in dopamine associated with Parkinson's disease alters the activity balance within the basal ganglia. Consequently, initiating movement can become more difficult, and the movement may become slower or smaller than intended. These changes contribute to the disease's characteristic motor symptoms, such as bradykinesia and rigidity [3, 5].

However, Parkinson's disease is not limited to dopamine or movement. Neurodegeneration affects wider areas of the nervous system, which helps explain why the disease can influence sleep, mood, cognition, sensory processing, and automatic body functions such as blood-pressure regulation and digestion [5].

Another characteristic pathological feature of Parkinson's disease is the abnormal accumulation of the protein alpha-synuclein, which is associated with structures known as Lewy bodies and Lewy neurites [5]. Therefore, the disease should be understood as a complex neurological disorder rather than simply a dopamine deficiency.

4. How Parkinson's Disease Affects the Body

Motor and non-motor symptoms can develop differently between individuals.

The characteristic motor features of Parkinson's disease are bradykinesia, rigidity, and resting tremor. Bradykinesia is characterized by slowness of movement and a reduction in the speed or amplitude of repetitive movements. Clinically, parkinsonism is defined as bradykinesia accompanied by either resting tremor or rigidity [6].

These symptoms can affect everyday activities, such as getting out of a chair, turning in bed, writing, reaching, and walking. Gait may become slower, steps may become shorter, arm swing may decrease, and turning may become more difficult. Some individuals also develop postural instability or freezing of gait, which is when forward progression temporarily stops despite the intention to continue walking [5].

More Than a Movement Disorder

Parkinson's disease can also cause non-motor symptoms affecting sleep, mood, thinking, smell, digestion, blood-pressure regulation, pain, fatigue, and bladder function. [5].

Some of these non-motor changes can occur before the characteristic movement symptoms become apparent. However, there is no set order in which Parkinson's disease develops. Symptoms, their severity, and their progression vary considerably between individuals [5].

5. How Parkinson's Disease Is Diagnosed

Symptoms, neurological examination, and response to treatment help clinicians identify the disease.

Currently, there is no routine test that can independently confirm a diagnosis of Parkinson's disease. Diagnosis is primarily clinical, based on medical history, symptoms, a neurological examination, and how the condition develops over time [5,6].

A central part of the diagnostic process is identifying parkinsonism. According to the Movement Disorder Society criteria, parkinsonism requires bradykinesia together with either resting tremor or rigidity [6]. Clinicians then consider additional features that support a diagnosis of Parkinson's disease or suggest another neurological condition.

A clear improvement in motor symptoms following dopaminergic treatment, such as with levodopa, can provide additional diagnostic information and is considered a supportive feature of Parkinson's disease [6]. However, the response to medication is considered in conjunction with the broader clinical picture, rather than being used as a standalone diagnostic test.

Brain imaging may be used when the clinical picture is unclear or when other causes of neurological symptoms need to be ruled out.

Describing Disease Severity

The Hoehn and Yahr scale is commonly used to describe the stages of motor impairment associated with Parkinson's disease [7]. Early stages may affect one side of the body primarily, while later stages can include bilateral symptoms, postural instability, and increasing difficulty with independent mobility.

However, a single stage cannot completely describe Parkinson's disease. The Hoehn and Yahr scale mainly focuses on motor function and does not capture the full range of nonmotor symptoms or individual variation [7].

6. Treating Parkinson's Disease

Medication, advanced therapies, and rehabilitation can help manage symptoms and maintain function.

Currently, there is no cure for Parkinson's disease. Therefore, treatment aims to reduce symptoms, maintain function and independence, and support quality of life [5].

Medication

Levodopa remains the most effective medication for alleviating the motor symptoms of Parkinson's disease. It is a dopamine precursor that can cross the blood-brain barrier. It is typically administered with carbidopa (Lodosyn) or benserazide (Madopar or Prolopa) to increase the amount that reaches the brain [8,9].

Depending on the individual's symptoms, disease stage, and response to treatment, other medications can also be used to stimulate dopamine receptors or help dopamine remain active for longer. [8].

As Parkinson's disease progresses, the effect of levodopa may become inconsistent. Some individuals experience periods when the medication works well, known as "ON" periods, which alternate with "OFF" periods when symptoms become more pronounced. Involuntary movements known as dyskinesias may also develop during long-term treatment [8].

Deep Brain Stimulation

For individuals whose motor symptoms or fluctuations are no longer adequately controlled by medication, deep brain stimulation (DBS) may be an option. DBS involves implanting electrodes that provide electrical stimulation to specific areas involved in movement regulation.

In appropriately selected individuals, DBS can reduce motor fluctuations, dyskinesias, tremor, rigidity, and bradykinesia [10]. However, DBS does not cure Parkinson's disease or stop its progression, and not all symptoms respond equally well.

7. Physical Therapy in Parkinson's Disease

Exercise and movement strategies can help maintain mobility and everyday function.

Physical therapy focuses on how a person moves and functions in everyday life. Treatment addresses strength, endurance, balance, walking, and functional mobility, and it is adapted according to the individual's symptoms and abilities [11].

Exercise, Strength, and Balance

Aerobic exercises such as walking, cycling, and treadmill training can help maintain cardiovascular fitness and physical capacity. Resistance exercises can improve the strength needed for everyday activities [11, 12].

Balance and functional training may include weight shifting, turning, stepping over obstacles, and practicing tasks such as standing up from a chair. These activities address movement difficulties that can affect independence and increase the risk of falling [11].

Gait and Movement Training

Gait training may involve overground or treadmill walking, taking larger steps, changing speed, turning, and navigating obstacles [11, 13].

Parkinson's disease can cause movements to become progressively smaller. Approaches such as LSVT BIG counteract this tendency by encouraging larger movements during exercises and functional activities [14].

Another strategy is external cueing. Auditory cues provide a walking rhythm, visual cues guide step placement, and tactile cues provide information through touch or vibration. Research indicates that cueing can improve aspects of gait; however, the response varies according to the cue, task, and individual [15, 16].

8. Cueing Technologies for Parkinson's Disease

Wearable systems are creating new ways to provide movement-related feedback during everyday walking.

Traditional cueing strategies are often employed in supervised therapy. Wearable technologies make it possible to deliver these cues during everyday movement [17].

Visual cues provide spatial targets for stepping, and auditory cues provide a rhythm to which steps can be synchronized. Vibrotactile cueing uses small vibrations applied to the body to provide movement-related information without requiring continuous visual or auditory attention [15, 16].

Recent research suggests that touch-based and vibrotactile cueing can improve gait characteristics, such as walking speed and stride length; however, evidence regarding long-term benefits remains limited [18].

Wearable systems can also use sensors to monitor walking in real time. Instead of providing continuous cues, future systems may detect changes in walking and deliver feedback only when needed. Recent research using sensor-equipped insoles has demonstrated that vibrations triggered by changes in stride characteristics can influence step length, heel-strike angle, and gait variability [19].

This progression from fixed cues toward responsive feedback creates opportunities for increasingly individualized rehabilitation. Because Parkinson's disease affects movement differently among individuals, the most useful support depends on the person, task, and environment. As wearable sensing and feedback technologies continue to advance, they may help individuals extend the movement strategies they practice in rehabilitation into their everyday lives.

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