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Effects of Various Therapeutic Exercises on Gait and Balance in Idiopathic Parkinson's Disease: A Narrative Review

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ABSTRACT

Background: Parkinson's disease (PD) is the second most prevalent neurodegenerative illness after Alzheimer's disease. It affects approximately 1-2 people per 1000, with prevalence increasing with age, impacting 1% of those over 60. The disease is characterized by the degeneration of dopaminergic neurons in the substantia nigra pars compacta, resulting in reduced dopamine levels in the striatum and leading to motor symptoms such as bradykinesia, rigidity, tremor, and postural instability. These motor impairments contribute to significant mobility and postural control issues, increasing the risk of falls and negatively affecting patients' quality of life. Freezing of gait is a common and challenging symptom that further complicates mobility and increases fall risk. Given the progressive nature of PD and its impact on motor function, this review aims to compile and assess the effectiveness of various therapies in enhancing gait and balance in individuals with Idiopathic Parkinson's Disease.

Objective: This narrative review aims to synthesize and evaluate the effectiveness of various therapeutic interventions designed to improve gait and balance function in patients with Idiopathic Parkinson's Disease.

Study Selection: A literature search was conducted across PubMed, Google Scholar, and Research Gate databases to identify relevant studies investigating interventions for gait and balance in PD.

KEYWORDS: Parkinson’s disease, Gait, Balance, Rehabilitation, Shaking palsy

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INTRODUCTION

Parkinson’s disease (PD) is a chronic, progressive neurodegenerative disorder that primarily affects the motor system due to the selective loss of dopaminergic neurons in the substantia nigra pars compacta. First described by James Parkinson in 1817 as the “shaking palsy,” PD is the second most common neurodegenerative disease after Alzheimer’s disease, with an estimated global prevalence of over 10 million individuals.[1] The disease predominantly affects individuals over the age of 60, though early-onset cases exist. Despite significant advances in research, the precise etiology of PD remains unclear, with genetic, environmental, and aging-related factors playing contributory roles in its onset and progression.[2]

The etiology of Parkinson’s disease is multifactorial, influenced by a combination of genetic and environmental factors. While the majority of PD cases are sporadic, around 10-15% have a hereditary component. Several genetic mutations have been linked to the disease, including those in the SNCA (alpha-synuclein), LRRK2 (leucine-rich repeat kinase 2), PARK2 (parkin), PINK1, and DJ-1 genes. Among these, mutations in SNCA are particularly significant, as alpha-synuclein is a primary constituent of Lewy bodies, a hallmark of PD pathology.[3] Environmental factors also play a crucial role, with prolonged exposure to pesticides, herbicides like paraquat and rotenone, and heavy metals being associated with an increased risk of developing PD. Living in rural areas and consuming well water have also

been suggested as environmental risk factors.[4] Aging remains the most important risk factor for PD, with age-related factors such as mitochondrial dysfunction, oxidative stress, and diminished neuroprotective mechanisms contributing to neuronal degeneration, particularly in older individuals.[5] These genetic and environmental factors together shape the onset and progression of Parkinson's disease.

The pathophysiology of Parkinson's disease (PD) is characterized by the degeneration of dopaminergic neurons in the substantia nigra, leading to a dopamine deficiency in the striatum and disrupted basal ganglia circuits, which impair motor control and cause typical PD symptoms like tremors and bradykinesia.[6] A key pathological feature is the presence of Lewy bodies, misfolded alpha-synuclein protein aggregates that contribute to neurotoxicity and neuronal loss.[7] Neuroinflammation, involving activated microglia and astrocytes, further exacerbates neurodegeneration. Mitochondrial dysfunction, particularly in complex I of the electron transport chain, leads to oxidative stress and neuronal apoptosis.[5] Additionally, prion-like propagation of misfolded alpha-synuclein spreads neurodegeneration across the central nervous system, driving disease progression.[7] These mechanisms collectively contribute to the progression of Parkinson's disease.

Parkinson's disease presents with a combination of motor and non-motor symptoms that worsen over time. Key motor symptoms include bradykinesia (slowness of movement), resting tremor (often asymmetric, pill-rolling), rigidity (increased muscle tone), and postural instability (leading to balance issues and falls in later stages).[1] Non-motor symptoms significantly affect quality of life, with cognitive impairment and dementia occurring in later stages, and depression and anxiety being common throughout. Autonomic dysfunction includes issues like orthostatic hypotension, constipation, and urinary problems, while sleep disorders such as REM sleep behavior disorder and excessive daytime sleepiness are prevalent. Olfactory dysfunction, or reduced sense of smell, is often an early symptom. These motor and non-motor features together shape the clinical presentation of PD.[3]

Although there is no cure for Parkinson's disease, treatment focuses on symptomatic relief through pharmacological therapies, physical and occupational therapies, and, in some cases, deep brain stimulation to improve motor function and quality of life.

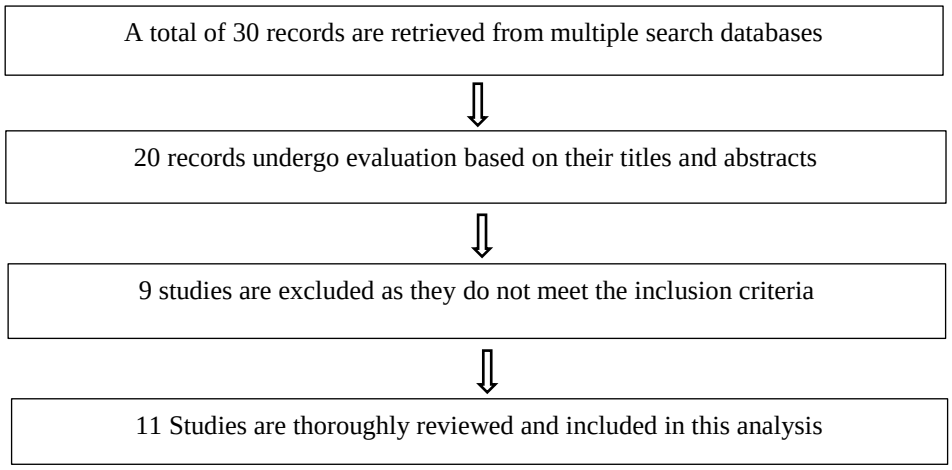
Pharmacological treatment is a cornerstone in managing Parkinson's disease (PD), primarily focused on enhancing dopamine activity in the brain. Levodopa (L-DOPA) is the most effective medication, converted into dopamine, and is commonly combined with carbidopa to prevent peripheral metabolism and ensure better central availability.[2] Dopamine agonists, such as pramipexole and ropinirole, mimic dopamine's action and are used in early stages of PD or as adjuncts to other therapies. Monoamine oxidase B (MAO-B) inhibitors, like selegiline and rasagiline, slow the breakdown of dopamine, prolonging its effects. Catechol-O-methyltransferase (COMT) inhibitors, including entacapone and tolcapone, extend the duration of levodopa's action by inhibiting its metabolism. Additionally, amantadine is prescribed to manage levodopa-induced dyskinesia, helping to reduce involuntary movements. These medications work synergistically to manage PD symptoms, improve motor control, and enhance the overall quality of life for patients.[8]

Deep Brain Stimulation (DBS) is a surgical treatment for advanced Parkinson's disease that involves implanting electrodes in the subthalamic nucleus or globus pallidus internus, effectively reducing motor fluctuations and dyskinesia.

Physiotherapy plays a vital role in the management of Parkinson's disease, aiming to improve mobility, balance, and functional independence in individuals with the condition. A comprehensive physiotherapy approach involves various strategies, such as aerobic exercise, which enhances neuroplasticity and motor performance, helping to reduce the progression of PD symptoms. Regular cardiovascular exercise, such as walking or cycling, promotes brain health and improves physical endurance. Balance and gait training techniques, including treadmill training, external cueing, and Tai Chi, significantly reduce the risk of falls and improve movement fluidity, addressing common motor impairments in PD. Additionally, strength training is essential for combating muscle rigidity and weakness, helping to maintain joint mobility and improve posture. One specialized approach, LSVT BIG Therapy, emphasizes large-amplitude movements to counteract bradykinesia, facilitating smoother and more effective motor function.[9] Finally, dual-task training enhances cognitive-motor interactions by challenging individuals to perform simultaneous tasks, improving both cognitive processing and motor performance during daily activities.[10] Together, these physiotherapy interventions contribute to better disease management, improving both the physical and cognitive aspects of life for those living with Parkinson's disease.

METHOD

This narrative review synthesized and evaluated the effectiveness of various treatments for improving gait and balance in individuals with Idiopathic Parkinson's Disease. Relevant studies were identified through searches of the PubMed, Google Scholar, and Research Gate databases. The keywords that search strategy employed are Parkinson's disease, Gait, Balance and Rehabilitation.



Authors, Journal, Year	Objectives	Design	Characteristics of participants sample size	Material and Methods	Outcomes Measures	Results
Ganesan, M., et al. (2014)[11]	To investigate the role of conventional gait training and partial weight-supported treadmill gait training (PWSTT) in improving the balance of patients with Parkinson disease (PD).	Prospective randomized controlled trial	N = 60 with PD fulfilling the United Kingdom Brain Bank PD diagnostic criteria	Patients were randomly assigned to 3 groups: Control**:** Dopaminomimetic drugs only. CGT (conventional gait training)**:** Drugs with conventional gait training. PWSTT**:** Drugs with PWSTT with 20% body weight unloading. Sessions lasted 30 minutes, 4 days a week, for 4 weeks (16 sessions).	The Unified Parkinson Disease Rating Scale (UPDRS), dynamic posturography, Berg Balance Scale, and Tinetti performance-oriented mobility assessment (POMA)	PWSTT may be a better interventional choice than CGT for gait and balance rehabilitation in patients with PD.
Patel NN, et al. (2017)[12]	Effect of otago exercises on balance and gait affection in patients with parkinson's disease	An interventional study	N = 20 Age 45 to 65 years. 1. No previous diagnosis of vestibular dysfunction. 2. History of	20 patients with Parkinson's disease with age group from 45-65 years were included. All the patients with Parkinson's disease were given a 6 weeks protocol of otago exercise to improve	Dynamic gait index, berg balance scale	The results suggest that both balance function (BBS) and gait function (DGI) are Improve but Gait function (DGI) is more

			fall. 3. Sufficient cognitive ability to participate, as indicated by MMSE 4. score of 24 or higher	balance and gait.		Improve than balance function (BBS) of the Parkinson's subjects.
Pandya S, et al. (2017)[13]	This study is to determine the effectiveness of Pilates Training over Conventional Balance Training on balance in participants with Idiopathic Parkinson's Disease.	An Interventional Study	N = 30 Idiopathic Parkinson's Disease Age Group:- < 65 years Both Males and Females Diagnosed with Idiopathic Parkinson's Disease (IPD) for over a year. On stable medication.History of falls or near-falls in the last two years. No prior physical therapy or regular exercise. MMSE score ≥24 (no significant cognitive impairment).	Group A was treated with Conventional Physiotherapy and Group B was treated with Pilates exercises with Conventional Physiotherapy.	Subjects were assessed at baseline and 7th week (post-intervention). Outcome measures were taken for BBS, ABC and TUG for assessment and analysis.	Pilates interevention with conventional balance training is more effective than conventional balance training alone to improve functional balance, confidence level and functional activities in participants with Idiopathic Parkinson's Disease.
Carroll, Louise M. et al. (2017)[14]	To evaluate the effects of aquatic exercise therapy on gait variability and disability compared with usual care for people with Parkinson	Single-blind randomized controlled trial.	N=21 Individuals with PD (Hoehn-Yahr stages I–III)	Participants were randomly assigned to either an aquatic exercise therapy group (45min, twice a week for 6wk) or a group that received usual care.	Primary Outcome: Gait variability (motion capture). Secondary Outcomes: Quality of life (PDQ-39), freezing	People in the aquatic therapy group and usual care group showed similar small improvements in gait variability.

	disease (PD).				of gait, motor disability (UPDRS). Feasibility: Safety, adverse events, participant satisfaction.	
U.Feng H, et al. (2019)[15]	The aim of this study was to investigate the effect of virtual reality (VR) technology on balance and gait in patients with Parkinson's disease (PD).	A single-blinded, randomized, controlled study.	N = 28 Hoehn-Yahr classification grade 2.5-4 age 50 to 70 years old; signed informed consent	The experimental group received VR training, and the control group received conventional physical therapy. Patients performed 45 minutes per session, 5 days a week, for 12 weeks.	Individuals were assessed pre- and post-rehabilitation with the Berg Balance Scale (BBS), Timed Up and Go Test (TUGT), Third Part of Unified Parkinson's Disease Rating Scale (UPDRS 3), and Functional Gait Assessment (FGA).	After treatment, BBS, TUGT, and FGA scores had improved significantly in both groups ($P<0.05$). However, there was no significant difference in the UPDRS3 between the pre- and post-rehabilitation data of the control group ($P>0.05$). VR training resulted in significantly better performance compared with the conventional physical therapy group ($P<0.05$).
Cabrera-Martos I, et al. (2020)[16]	To explore the effects of an eight-week core stability program on balance ability in	Randomized controlled trial.	N = 44 aged 30 years or older and being diagnosed with Parkinson's disease 2 or 3 on the	The experimental group received 24 sessions of core training, while the control group received an intervention including active	Primary Outcome: Mini-Balance Evaluation Systems Test.	After treatment, a significant between-group improvement in dynamic balance was

	persons with Parkinson's disease.		Hoehn and Yahr scale	joint mobilization, muscle stretching, and motor coordination exercises.	Secondary Outcomes: Activities-specific Balance Confidence Scale. Standing balance (Maximal excursion of center of pressure, Modified Clinical Test of Sensory Interaction on Balance, Limits of Stability test).	observed in the experimental group compared to the control group
Çoban F, et al. (2021)[17]	To compare effects of clinical Pilates and conventional physiotherapy exercises on balance and postural control in Parkinson's disease	A randomized controlled trial	N = 40 patients with Hoehn and Yahr stage 2–3 PD aged 45–70 years who had a Mini-Mental Test (MMT) score of at least 26 and had PD for a minimum of 2 years	Patients were randomly assigned into either clinical Pilates (CLP) or conventional physiotherapy (COP) group. Exercises were performed twice a week for 8 weeks.	One-leg stance (OLS) test and tandem stance test (TST) functional reach test (FRT) TUG test 30-second chair-stand test Berg Balance Scale (BBS)	Study showed that clinical Pilates exercises had positive effects on balance, functional mobility, lower-extremity strength and fall risk in individuals with PD
Gaßner H, et al. (2022)[18]	The aim of this study was to investigate	A randomized	N = 105 age between 30 and 90 years and	Patients were randomly assigned into either Treadmill group or	Primary outcomes included	Both interventions significantly improved gait

	the impact of individualized physiotherapy or treadmill training on gait during dual task performance.	controlled trial	Hoehn and Yahr disease stage between I and III. Treadmill Endurance Handrail Independence Cognitive Ability	Physiotherapy group. Both groups received 10 individual interventional sessions of 25 min each and additional group therapy sessions for 14 days.	gait speed and clinically relevant gait parameters, such as stride length and swing time Secondary outcomes were the UPDRS-III and the Berg Balance Scale (BBS)	speed and additional gait parameters during dual task walking as well as clinical parameters and walking capacity in patients.
Biebl JT, et al. (2022)[19]	The objective of this study is to evaluate and compare the effects of two integrative interventions on gait and balance of patients with PD.	A randomized controlled pilot study	N = 36 Patients diagnosed with PD according to the Queen Square Brain Bank criteria, Hoehn and Yahr stage II-III	Group A received resistance training in combination with gait training (gait resistance training, GRT) or Group B received resistance training in combination with balance training (stability resistance training, SRT) twelve sessions lasting 30 minutes over six weeks.	Primary outcomes: functional reach (balance) and stride length (gait). Secondary outcomes: gait analysis, knee strength, timed up and go, and six-minute walk test.	Integrative therapies, combining gait or balance training with resistance training, have specific positive effects in PD rehabilitation.
T.S Megha,et al. (2023)[20]	To determine the effect of core muscle training on improving	A randomized controlled trial	N = 30 clinically diagnosed cases of IPD, 2, 2.5, 3 Modified Hoehn and	Group A received core muscle training, with conventional exercise while Group B received conventional	Tinetti POMA – Balance component and Functional Gait	Core muscle training along with conventional physiotherapy are effective in

	balance and gait performance in Idiopathic Parkinson's disease		Yahr staging, age 50-65 years, on stage of levodopa, MoCA score greater than or equal to 26.	physiotherapy alone. Duration of treatment was 5 days /week for 6 weeks.	Assessment (FGA) used to assess balance and gait respectively.	improving balance and gait performance in Idiopathic Parkinson's disease.
Tariq S, et al. (2025)[21]	To compare the effects of virtual reality rehabilitation and task-oriented training on dynamic balance and gait performance among patients with Parkinson's disease.	A comparative randomized controlled trial	A total of 28 patients diagnosed with PD (Hoehn and Yahr stages 2–3), aged 50–70 years	Group A received VR-based training sessions, while Group B underwent task-oriented exercises, with both interventions delivered thrice weekly for eight weeks.	Outcomes were assessed using the Berg Balance Scale (BBS), Timed Up and Go Test (TUG), and Functional Gait Assessment (FGA).	Both interventions significantly improved balance and gait in Parkinson's patients. However, VR rehabilitation demonstrated superior efficacy, emphasizing its potential as a more effective therapeutic modality.

DISCUSSION

The studies included in this review highlight a variety of therapeutic interventions aimed at addressing gait and balance impairments in individuals with Idiopathic Parkinson's Disease. A consistent finding across several studies is the positive impact of exercise-based interventions. Studies investigating Otago exercises, Pilates training, core stability programs, VR training, treadmill training and aquatic exercise therapy all demonstrated improvements in balance and gait parameters, reinforcing the importance of exercise as a key component of PD management. For instance, Patel NN, et al. (2017) found that Otago exercises improved both balance and gait function in Parkinson's subjects.

Gaßner H et al. (2022) revealed that both individualized physiotherapy and treadmill training effectively improve gait during dual-task performance, a crucial aspect for maintaining safe and independent walking. Similarly, T.S Megha, et al. (2023) demonstrated that core muscle training, when combined with conventional physiotherapy, leads to significant improvements in balance and gait performance. The use of technology-driven interventions, particularly virtual reality (VR) training, was explored in a few studies. Feng H, et al. (2019) indicated that VR training can be a valuable tool for enhancing balance and gait in PD patients. Notably, Tariq S, et al. (2025) suggested that VR rehabilitation may offer superior efficacy compared to task-oriented training. While the majority of studies reported positive outcomes, there are variations in study design and participant characteristics that make direct comparisons challenging. These variations include differences in sample size, participant age ranges, disease severity (e.g., Hoehn-Yahr stage), and the duration of the interventions.

Furthermore, the studies utilized a range of outcome measures to assess balance and gait, such as the Berg Balance Scale (BBS), Dynamic Gait Index (DGI), Timed Up and Go Test (TUGT), Functional Gait Assessment (FGA), and Tinetti performance-oriented mobility assessment (POMA). This heterogeneity in outcome measures can limit the ability to synthesize findings and draw definitive conclusions about the most effective interventions. For example, while some studies used the BBS to assess balance, others used the Mini-Balance Evaluation Systems Test or dynamic posturography.

CONCLUSION

The reviewed studies suggest that exercise-based therapies, including Otago exercises, Pilates training, core stability training, treadmill training, and aquatic exercise therapy, demonstrate potential benefits for enhancing gait and balance in individuals with PD. Furthermore, technology-driven approaches, such as virtual reality (VR) training, show

promise as a valuable modality for motor rehabilitation in this population. However, heterogeneity in study designs, participant characteristics, intervention parameters, and outcome measures across the included studies limits the ability to draw definitive conclusions regarding the most effective interventions and highlights the need for further standardized research.

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