A Literature Review on the Effects of Physiotherapy on Bradykinesia in Parkinson's Disease

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Abstract- Bradykinesia, characterized by slowness and reduced amplitude of voluntary movement, is one of the most disabling symptoms of Parkinson's disease (PD). Despite advances in pharmacological treatment, bradykinesia often persists or worsens with disease progression, impairing independence and functional ability. Physiotherapy has emerged as a critical, evidence-based, non-pharmacological strategy targeting motor re-education, amplitude enhancement, and neuroplastic adaptation.

This review consolidates and examines twenty recent peer-reviewed studies published between 2012 and 2025 that investigate the impact of various physiotherapy interventions on bradykinesia in PD. Interventions assessed include amplitude-based movement training (LSVT-BIG), rhythmic auditory cueing, treadmill and robotic gait training, aerobic and resistance exercises, and multimodal neurophysiological rehabilitation programs.

Findings reveal that physiotherapy interventions emphasizing task-specific, high-intensity, and repetitive motor practice significantly improve movement velocity, amplitude, and coordination. Furthermore, multimodal programs combining cueing, amplitude training, and endurance exercises demonstrated longer-lasting improvements compared to isolated techniques.

Overall, the evidence supports physiotherapy as a cornerstone in managing bradykinesia through mechanisms of motor learning and neuroplasticity. The review underscores the need for individualized, sustained rehabilitation protocols integrating innovative, technology-assisted approaches for enhanced outcomes.

Keywords: Parkinson's disease, Bradykinesia, Physiotherapy, Neuroplasticity, LSVT-BIG, Cueing, Exercise therapy, Motor learning

I.INTRODUCTION

Parkinson's disease (PD) is a chronic, progressive neurodegenerative disorder characterized by the loss of dopaminergic neurons in the substantia nigra pars compacta of the midbrain. This degeneration leads to dopamine depletion in the basal ganglia, which disrupts the regulation of voluntary motor control. The resulting motor impairments—tremor, rigidity, postural instability, and bradykinesia—form the cardinal symptoms of PD. Among these, bradykinesia, or slowness in initiating and executing movement, is considered the most disabling and functionally limiting symptom.

Bradykinesia contributes significantly to gait disturbances, balance deficits, difficulty in fine motor activities, and reduced participation in daily life. The symptom stems not merely from muscular weakness but from impaired central motor processing, resulting in reduced movement amplitude and velocity. It is closely linked to abnormalities within the basal ganglia-thalamocortical circuitry, which alter motor output scaling and internal cueing mechanisms. While pharmacological therapy, particularly levodopa, remains the cornerstone of PD management, long-term drug use often leads to motor fluctuations, dyskinesias, and diminishing response to medication. Consequently, physiotherapy has become a vital non-

pharmacological adjunct to address functional mobility, posture, coordination, and movement initiation.

Physiotherapy interventions are designed to enhance motor learning, stimulate cortical plasticity, and recalibrate the internal representation of movement amplitude. Programs such as LSVT-BIG, treadmill and robotic gait training, rhythmic auditory stimulation (RAS), dual-task balance training, and aerobic or resistance exercises aim to restore effective motor patterns through intensive, repetitive, and task-specific practice. These approaches also encourage external cueing strategies to bypass defective basal ganglia pathways and engage alternative cortical networks for improved motor execution. The importance of physiotherapy in PD extends beyond symptom management—it also improves quality of life, independence, and participation in social and physical activities. The present review explores current evidence from twenty selected studies to identify the most effective physiotherapy interventions for mitigating bradykinesia and improving overall motor function in Parkinson's disease.

II. NEED FOR THE STUDY

Although pharmacological management remains central to Parkinson's disease treatment, bradykinesia frequently persists despite optimized medication. The symptom's complex pathophysiology—stemming from impaired motor planning, reduced feedback control, and defective internal cueing—requires more than dopaminergic replacement alone. Physiotherapy provides an essential, complementary role in addressing these deficits through behavioral and neuroplastic strategies.

The diversity of available physiotherapy interventions—ranging from amplitude-based training, cueing therapies, treadmill and robotic-assisted gait training, dual-task training, resistance and aerobic exercises, and virtual-reality-based rehabilitation—highlights the need to evaluate and compare their effectiveness systematically. A review of this kind helps clinicians identify which physiotherapy methods yield the greatest functional and neurophysiological benefits for managing bradykinesia. It also aids in guiding the development of standardized rehabilitation protocols adaptable to various disease stages and healthcare settings.

III. OBJECTIVES

The specific objectives of this literature review are:

1. To analyze and summarize existing research on physiotherapy interventions designed to alleviate bradykinesia in Parkinson's disease.
2. To identify and compare the effectiveness, advantages, and limitations of amplitude-based, cueing-based, and multimodal physiotherapy approaches.
3. To provide evidence-based recommendations for clinical practice and future research in the physiotherapeutic management of bradykinesia.

IV. METHODOLOGY

This literature review was conducted using a systematic approach to identify, evaluate, and synthesize studies exploring the effects of physiotherapy on bradykinesia in Parkinson's disease.

Data Sources and Search Strategy

Comprehensive searches were carried out using PubMed, Scopus, Google Scholar, and the Cochrane Library databases. The time frame selected for review spanned from 2012 to 2025 to include the most recent developments in physiotherapy and neurorehabilitation. The following keywords and Boolean combinations were used:

"Parkinson's disease" AND "bradykinesia," "physiotherapy," "rehabilitation," "task-specific training," "cueing," "amplitude-based therapy," "gait training," and "exercise intervention."

Inclusion Criteria

- Studies published in English.
- Participants diagnosed with idiopathic Parkinson's disease.
- Randomized controlled trials (RCTs), quasi-experimental studies, systematic reviews, and meta-analyses.
- Research examining physiotherapy-based interventions specifically targeting bradykinesia or motor control.

Exclusion Criteria

- Studies focusing exclusively on pharmacological or surgical interventions.
- Animal-based or simulation studies.
- Case reports and pilot studies without statistical outcomes.

Data Extraction and Synthesis

Each study was evaluated for design, sample size, intervention type, duration, outcome measures, and key findings. Results were categorized into thematic domains—amplitude-based training, cueing, treadmill and robotic gait training, aerobic/resistance exercise, and multimodal interventions—to facilitate comparison.

Flowchart of Study Selection:

Records identified through database search (n = 126)
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Titles and abstracts screened (n = 88)
↓
Full-text articles assessed for eligibility (n = 34)
↓
Excluded (n = 12) – non-physiotherapy or unrelated outcomes
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Studies included in final review (n = 22)

No.	Author (Year)	Intervention	Outcome Focus	Key Findings
1	Benfica (2024)	Speed-based task training	Movement velocity	Significant improvement in speed and amplitude.
2	Ye (2022)	Rhythmic auditory stimulation	Gait parameters	Enhanced stride length and gait rhythm.
3	Earhart (2012)	Treadmill training	Walking endurance	Improved walking efficiency and motor fluency.
4	Peterka (2020)	LSVT-BIG	Motor amplitude	Increased movement amplitude and coordination.
5	Ghai (2018)	Auditory cueing	Gait velocity	Better step timing and movement initiation.
6	Schenkman (2018)	High-intensity aerobic training	Motor performance	Improved UPDRS motor scores and initiation speed.
7	Shulman (2013)	Exercise comparison	Strength and balance	All interventions beneficial; specific gains per modality.
8	del Olmo (2006)	Cueing for repetitive tasks	Coordination	Reduced sequence effect and improved rhythm.
9	Capecci (2019)	Robot-assisted gait training	Mobility	Comparable improvements to treadmill-based gait training.
10	Terasawa (2023)	Outpatient physiotherapy	Axial symptoms	Improved axial control and reduced bradykinesia.
11	Clinical Trials (2023)	Speed-dependent treadmill	Dual-task walking	Enhanced gait performance under dual-task conditions.
12	Iwai (2024)	LSVT-BIG observational study	Movement amplitude	Increased upper limb reach and amplitude during tasks.
13	Muthukrishnan (2019)	Cueing paradigms review	Initiation & timing	External cues help bypass basal ganglia deficits.
14	Cochrane (2019)	Systematic synthesis	Multiple modalities	Moderate-to-high evidence supporting physiotherapy.
15	Tufft (2025)	FES (Functional Electrical Stimulation)	Gait speed	Feasible; improved walking speed and stability.
16	Sarasso (2024)	Neurophysiology-based rehabilitation	Motor control	Improved cortical activation and motor consistency.
17	Janssens (2014)	LSVT-BIG RCT	Motor outcomes	Significant amplitude and movement velocity gains.

18	IJHSR (2020)	LSVT vs conventional therapy	ADL & gait	LSVT yielded superior outcomes in ADL and gait.
19	Boccali (2025)	Treadmill meta-analysis	Gait outcomes	Strong evidence for treadmill-induced gait enhancement.
20	Stegemöller (2023)	Cue-based tapping	Motor rhythm	Improved consistency, speed, and timing.
21	Suganthirababu.p(2025)	Task specific training	Cognitive function	Improved motor function
22	Holmarsdottir,t.r(2025)	Agility training	Balance and functional performance	Showed great improvement in both balance and also functional performance

V. RESULTS

The synthesis of twenty-two research studies revealed consistent evidence that physiotherapy interventions substantially improve bradykinesia and overall motor performance in patients with Parkinson's disease. The majority of studies reported statistically significant improvements in movement velocity, amplitude, stride length, coordination, and postural control following structured physiotherapy programs.

Amplitude-Based Training (e.g., LSVT-BIG)

Multiple randomized controlled trials (Peterka, 2020; Janssens, 2014; IJHSR, 2020) demonstrated that LSVT-BIG interventions result in measurable gains in motor amplitude, gait speed, and daily living performance. The technique's intensive, high-effort model recalibrates internal movement perception and enhances the magnitude of voluntary movements. However, the program's rigorous nature requires specialized therapist certification and patient motivation.

Cueing and Auditory Stimulation

Cueing interventions, such as rhythmic auditory stimulation (Ye, 2022; del Olmo, 2006; Stegemöller, 2023), significantly improved timing, stride length, and gait rhythmicity. By providing external sensory cues, these methods bypass impaired basal ganglia pathways and synchronize motor output. Nevertheless, some studies noted that effects may diminish when cueing is withdrawn, emphasizing the importance of ongoing cue exposure and home-based continuation.

Treadmill and Robotic Gait Training

Treadmill and robotic-based interventions (Earhart, 2012; Capecci, 2019; Boccali, 2025) demonstrated considerable improvements in walking endurance, dual-task performance, and postural alignment. Robot-assisted systems provided enhanced safety and repetition, particularly for patients with balance impairments. However, accessibility and equipment cost remain major limitations in clinical settings.

Aerobic and Resistance Exercises

Aerobic and resistance exercises (Schenkman, 2018; Shulman, 2013) enhanced cardiovascular fitness, strength, and motor initiation, contributing indirectly to improved motor speed and endurance. Such programs may also promote neurotrophic factor release (e.g., BDNF), supporting long-term neuroplastic adaptation.

Multimodal Approaches

Integrated, multimodal interventions (Terasawa, 2023; Cochrane, 2019; Sarasso, 2024) combining amplitude-based, cueing, and endurance components yielded the broadest functional benefits. These approaches effectively addressed multiple motor impairments simultaneously and sustained improvements over time.

Overall, the evidence supports physiotherapy as a highly effective, adaptable, and sustainable treatment modality for mitigating bradykinesia and improving functional independence in Parkinson's disease.

VI. DISCUSSION

The synthesis of twenty research studies provides strong evidence supporting the effectiveness of physiotherapy as a crucial therapeutic strategy for mitigating bradykinesia in Parkinson's disease (PD). Across all reviewed literature, a consistent pattern emerges — structured physiotherapy interventions lead to measurable improvements in movement velocity, amplitude, and coordination, all of which are essential for functional independence and quality of life in individuals with PD. The studies collectively emphasize that bradykinesia is not merely a symptom of muscle rigidity or weakness, but a consequence of

disrupted neural communication within the basal ganglia–thalamocortical circuitry. Therefore, the success of physiotherapy lies in its ability to retrain motor control mechanisms through repetition, external cueing, amplitude calibration, and neuroplastic adaptation.

Benfica (2024) highlighted the use of speed-based task training, showing that repetitive, high-speed functional tasks significantly improve movement velocity and reaction time in PD patients. This supports the principle that bradykinesia can be reduced when training emphasizes velocity as a core motor target. Ye (2022) demonstrated that rhythmic auditory stimulation (RAS) effectively improved gait rhythm, step length, and walking cadence by engaging auditory–motor synchronization networks. These results underscore how external sensory cues compensate for internal cueing deficits caused by dopaminergic loss. Similarly, Earhart (2012) found that treadmill training increased walking endurance and smoothness of gait, likely due to the consistent feedback and structured environment it provides.

Peterka (2020) and Janssens (2014) both reported that LSVT-BIG training, an amplitude-based physiotherapy technique, led to significant improvements in movement amplitude, postural alignment, and functional tasks such as dressing and turning. The exaggerated, high-amplitude exercises used in LSVT-BIG recalibrate the brain's perception of movement size, thereby addressing one of the key deficits in bradykinesia — the underestimation of movement amplitude. Ghai (2018) and del Olmo (2006) confirmed that auditory cueing techniques improve rhythmic control, stride regulation, and timing consistency, while also reducing freezing of gait episodes. These findings reinforce the role of external feedback in reprogramming impaired motor circuits.

Schenkman (2018) and Shulman (2013) expanded the evidence by demonstrating the systemic and neurological benefits of aerobic and resistance training. Their work revealed that such programs enhance cardiovascular capacity, muscular strength, and motor initiation speed. Moreover, they promote neurotrophic factor release, particularly brain-derived neurotrophic factor (BDNF), which supports synaptic plasticity and neuroprotection — mechanisms vital for sustaining motor performance in PD. Similarly, Capecci (2019) and Terasawa (2023) investigated robot-assisted and outpatient physiotherapy, reporting significant improvements in stability, dual-task gait performance, and overall functional mobility. These interventions emphasize the role of technological support in achieving high-intensity, task-specific practice, especially in patients with balance deficits.

The ClinicalTrials (2023) study confirmed that speed-dependent treadmill training improves dual-task walking ability and overall gait dynamics, suggesting that adaptive treadmill systems can help recondition the motor system. Iwai (2024) provided observational evidence that LSVT-BIG therapy, when performed consistently over multiple weeks, sustains gains in limb amplitude and coordination beyond the therapy period. Muthukrishnan (2019) and the Cochrane (2019) systematic review both synthesized evidence across cueing and amplitude-based methods, concluding that these interventions have moderate-to-high efficacy in improving gait speed, motor control, and activities of daily living (ADL).

Emerging evidence from Tufft (2025) and Sarasso (2024) introduced novel techniques such as Functional Electrical Stimulation (FES) and neurophysiological rehabilitation, demonstrating improvements in cortical activation and motor coordination. These studies highlight the potential of combining electrical stimulation with conventional exercise to accelerate motor relearning. Janssens (2014), IJHSR (2020), and Boccali (2025) reported that both amplitude-based and treadmill interventions produce measurable and sustainable gains in movement amplitude, rhythm, and postural control. Lastly, Stegemöller (2023) emphasized that cue-based rhythmic tapping enhances timing precision and coordination, supporting its use as an adjunct to conventional physiotherapy.

Among all the articles discussed above, a few techniques were found to be significantly more effective and clinically relevant for reducing bradykinesia and enhancing motor outcomes. The most prominent among them include amplitude-based interventions such as LSVT-BIG, rhythmic auditory cueing, treadmill and robotic-assisted gait training, and multimodal rehabilitation programs. These approaches consistently demonstrate superior outcomes due to their grounding in neuroplasticity principles, high-intensity repetition, and real-time feedback mechanisms. The combined use of external cueing and amplitude amplification retrains the motor

cortex to produce larger, faster, and more controlled movements.

Furthermore, studies integrating multimodal components — combining amplitude training, auditory feedback, and endurance exercises — yielded the broadest improvements in motor performance, postural stability, and ADL independence. Such programs encourage neural reorganization through repetitive task practice, strengthening the cortico-striatal pathways responsible for voluntary motor control. These findings collectively affirm that physiotherapy not only mitigates the physical symptoms of PD but also enhances neurophysiological efficiency, fostering long-term adaptation and functional independence.

In summary, physiotherapy emerges as a cornerstone of non-pharmacological management for Parkinson's disease. The reviewed literature emphasizes that effective intervention is grounded in individualized, intensive, and feedback-driven programs tailored to disease stage and patient capacity. As research continues to evolve, the integration of technology-based systems — including virtual reality, wearable sensors, and tele-rehabilitation platforms — promises to expand the accessibility and effectiveness of physiotherapy for patients worldwide.

Additionally, Suganthirababu (2025) highlighted the importance of task-specific training in improving motor amplitude, cognitive engagement, and functional independence through repetitive, goal-oriented activities that promote neuroplastic adaptation. Similarly, Holmarsdottir, Sigurgeirsson, and Agustsson (2025) found that agility-based drills incorporating rapid, multidirectional light-based movements significantly improved dynamic balance, reaction time, and lower-limb coordination, indirectly enhancing control over bradykinesia by promoting sensorimotor responsiveness.".

VII. CONCLUSION

The collective evidence from the reviewed studies underscores that physiotherapy plays an essential and irreplaceable role in managing bradykinesia in individuals with Parkinson's disease. By focusing on neuroplasticity, task-specific learning, and external cueing, physiotherapy enhances both the physiological and functional aspects of motor performance. Among all evaluated interventions, amplitude-based programs such as LSVT-BIG and cueing-based approaches have consistently demonstrated the most significant improvements in movement velocity, amplitude, and coordination. These therapies help recalibrate the perception of movement size and timing, thereby restoring voluntary motor control.

Treadmill and robotic gait training interventions further contribute to gait regularity, endurance, and postural balance, offering safety and structured repetition for patients at varying disease stages. Meanwhile, aerobic and resistance exercises augment overall physical conditioning and neural activation, enhancing the body's ability to respond adaptively to movement demands.

The best therapeutic outcomes are achieved when multiple physiotherapy modalities are integrated within individualized, progressive programs. Such multimodal approaches yield cumulative benefits by addressing different aspects of bradykinesia — from amplitude enhancement to rhythm regulation and endurance training.

Physiotherapists must, therefore, tailor interventions according to patient capability, disease severity, and therapeutic goals, while ensuring intensity, repetition, and patient engagement remain at the core of every treatment plan. Continued research should explore the use of technology-assisted rehabilitation (e.g., wearable sensors, virtual reality, and telerehabilitation platforms) to extend accessibility and promote sustained practice beyond clinical settings. Ultimately, physiotherapy stands as the cornerstone of holistic Parkinson's disease management — not only improving physical function but also preserving independence and quality of life.

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