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Physiotherapy Interventions for Movement Disorders in Parkinson's Disease: A Scoping Review of Targeted Treatment Approaches

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Abstract

Background: Parkinson's disease (PD) presents with heterogeneous movement disorders, including bradykinesia, rigidity, tremor, postural instability, and gait dysfunction. While conventional physiotherapy broadly addresses PD symptoms, movement disorder-specific interventions may optimize therapeutic outcomes through targeted mechanisms.

Objective: To map the current evidence of physiotherapy interventions specifically designed to address individual movement disorders in PD, evaluate effectiveness, and identify knowledge gaps for future research.

Methods: A scoping review following the Arksey and O'Malley framework searched PubMed, CINAHL, Embase, and Web of Science from 2012 to 2025. Fifteen sources were included: eight systematic reviews/meta-analyses, four scoping reviews, and three clinical guidelines. Data were charted according to movement disorder type, intervention characteristics, and evidence quality.

Results: Twelve physiotherapy intervention categories targeting specific motor impairments in patients with PD were identified. Progressive resistance and amplitude-focused training showed evidence of bradykinesia management. Treadmill training has been shown to benefit gait parameters. Cueing strategies were effective for freezing of gait episodes. Balance training improves functional mobility. Dance therapy, martial arts, virtual reality, and aquatic therapy have shown potential benefits for motor symptoms and quality of life. Most studies reported short-term outcomes with limited long-term follow-up.

Conclusions: Movement disorder-specific physiotherapy interventions are promising for targeted symptom management in patients with PD. Evidence supports resistance training for bradykinesia, cueing strategies for freezing of gait, and treadmill training for gait dysfunction; however, effect sizes and long-term benefits require further investigation. Significant knowledge gaps exist in terms of comparative effectiveness, personalized treatment selection, and sustained benefits. Future research should focus on head-to-head comparisons, standardized outcome measures and longer follow-up periods.

Keywords: Parkinson's disease; Physiotherapy; Movement disorders; Rehabilitation; Targeted interventions

1. Introduction

Parkinson's disease affects millions of people worldwide and is characterized by the progressive degeneration of dopaminergic neurons in the substantia nigra. [1] The cardinal motor symptoms of bradykinesia, tremor, rigidity, and postural instability significantly impact functional mobility and quality of life. While pharmacological interventions

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remain the primary treatment, motor symptoms may show variable responses to medications, particularly as the disease progresses. [2,3]

Physiotherapy plays a pivotal role in non-pharmacological management, aiming to enhance motor function, independence, and participation in patients. This scoping review maps targeted physiotherapy approaches by identifying intervention types, targeted symptoms, and available evidence to inform clinical practice and highlight areas for future research. [4,5]

2. Methods

2.1. Study Design

This scoping review was conducted in accordance with the methodological framework proposed by Arksey and O'Malley and further refined by Levac et al., following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) guidelines. This approach was selected to comprehensively map the available evidence on physiotherapy interventions targeting specific movement disorders in Parkinson's disease (PD), rather than to provide a pooled estimate of intervention effectiveness.

2.2. Search Strategy

A systematic and comprehensive literature search was conducted across four electronic databases: PubMed/MEDLINE, CINAHL, Embase, and the Web of Science. The search covered studies published from January 2012 to August 2025 to capture contemporary clinical practice. The search strategy combined controlled vocabulary (e.g., MeSH and Emtree) with free-text terms. Keywords included: *"Parkinson's disease," "bradykinesia," "rigidity," "tremor," "postural instability," "gait dysfunction," "freezing of gait," "physiotherapy," "physical therapy," "rehabilitation," "exercise therapy."* Hand-searching of reference lists from the included studies was conducted to identify additional relevant sources. No language or publication status restrictions were applied beyond the inclusion criteria of this study.

2.3. Eligibility Criteria

Studies were considered eligible if they met the following criteria.

- **Population:** Adults with idiopathic Parkinson's disease.
- **Interventions:** Physiotherapy or exercise-based interventions explicitly designed to target one or more movement disorders (e.g., bradykinesia, freezing of gait, gait hypokinesia, balance dysfunction, rigidity, and postural instability).
- **Study Design:** Systematic reviews, meta-analyses, scoping reviews, clinical guidelines, randomized controlled trials, or quasi-experimental studies.
- **Outcomes:** At least one motor outcome measure relevant to the targeted symptom, such as the Unified Parkinson's Disease Rating Scale (UPDRS), Berg Balance Scale, gait speed, stride length, or Freezing of Gait Questionnaire.
- **Publication Characteristics:** Peer-reviewed, English-language studies published between 2012 and 2025.

A pilot screening exercise was conducted on a subset of records to ensure consistency between the reviewers before the full screening commenced.

Studies were excluded if they (1) focused on pharmacological, surgical, or non-physiotherapy interventions; (2) described only generic physiotherapy without disorder-specific targeting; (3) included participants with atypical or secondary Parkinsonism; or (4) were case reports, conference abstracts, or non-peer-reviewed sources.

2.4. Study Selection

The search results were exported to reference management software, and duplicates were removed. Two independent reviewers screened the titles and abstracts for relevance, followed by full-text screening of potentially eligible articles. Inter-rater reliability was calculated using Cohen's kappa coefficient. Discrepancies were resolved through discussion or, when necessary, by consulting a third reviewer. The study selection process was documented using a PRISMA-ScR flowchart.

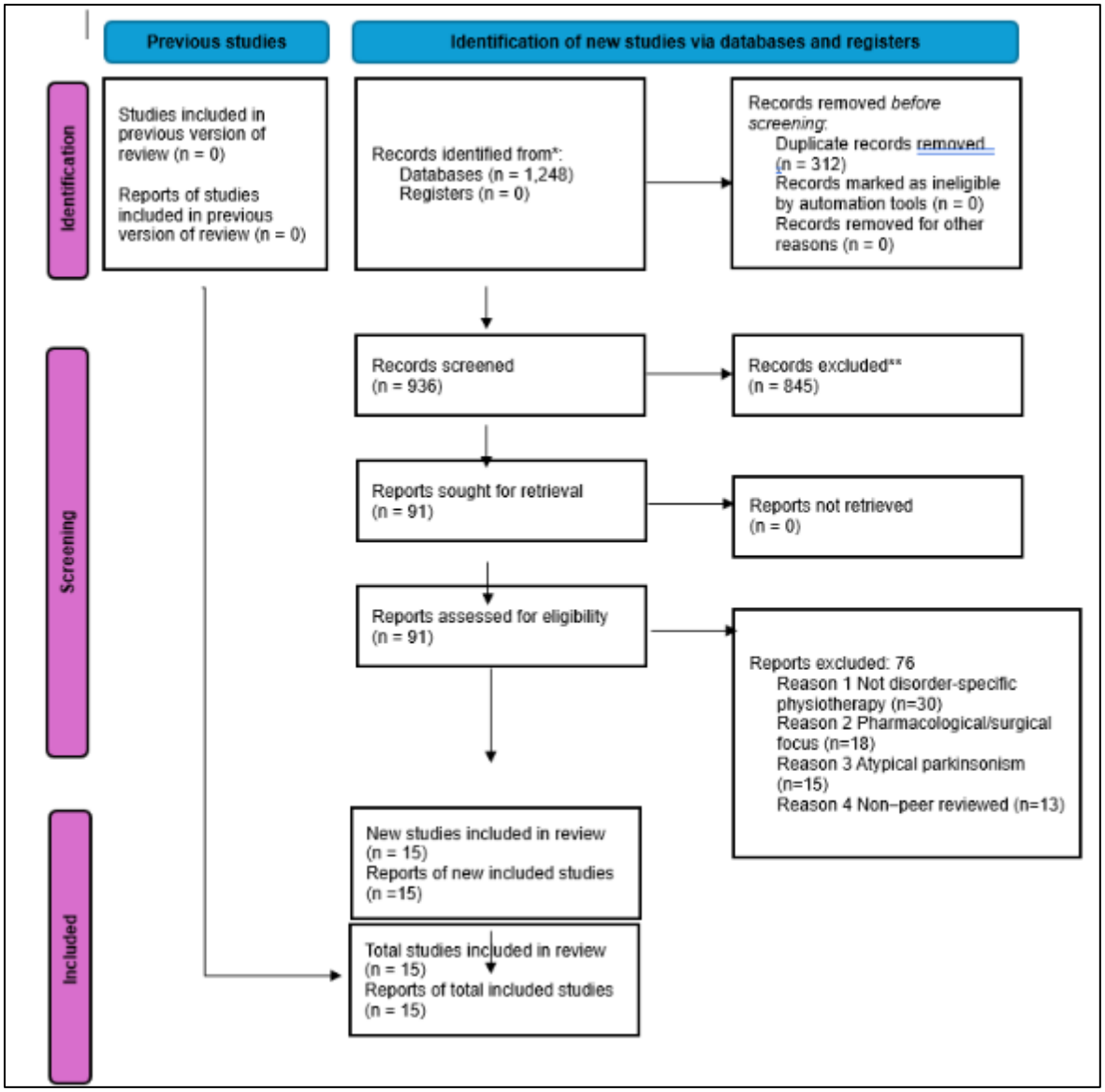

Figure 1 PRISMA-ScR flow diagram of the study selection

2.5. Evidence Synthesis

Data were synthesized narratively and organized thematically by movement disorder type and intervention category. A descriptive summary approach was used to present the findings, with tabulation of the study characteristics and key outcomes. No quantitative synthesis or meta-analysis was performed, which is consistent with the scoping review methodology.

3. Results

3.1. Study Selection

The database search identified 1,248 records screened. After the removal of 312 duplicates, 936 records remained for title and abstract screening. Of these, 845 were excluded as being irrelevant. Ninety-one full-text articles were assessed for eligibility, and 76 were excluded for reasons such as non–movement disorder-specific interventions, pharmacological or surgical focus, atypical parkinsonism, or non-peer-reviewed sources. Fifteen sources were included in the final review: eight systematic reviews/meta-analyses, four scoping reviews, and three clinical guidelines.

3.2. Characteristics of Included Studies

The included systematic reviews reported on studies with varying sample sizes and participant characteristics, with a mean age of 60–75 years. Disease severity covered Hoehn and Yahr stages 1–4. The reviewed studies examined interventions delivered across various settings, including clinic-based, home-based, and community-based programs. The intervention duration ranged from 4 to 52 weeks.

3.3. Overview of Physiotherapy Interventions

Twelve physiotherapy intervention categories were identified, each targeting specific motor impairments in Parkinson's disease, including bradykinesia, gait dysfunction, freezing of gait, postural instability, balance deficits, rigidity, and, to a lesser extent, tremor. The categories, associated outcomes, evidence levels, and representative studies are summarized in Table 1.

Table 1 Summary of Physiotherapy Interventions Targeting Movement Disorders in Parkinson's Disease

Intervention Category	Targeted Movement Disorders	Key Outcomes Improved	Evidence Level (GRADE)	Example Studies
Conventional Physiotherapy (e.g., Bobath, hands-on techniques, education)	Bradykinesia, rigidity, gait disturbances	Improvements in UPDRS motor scores, gait speed, and balance measures	Moderate-High	Tomlinson et al. (2012) [6]
Aerobic Exercise (e.g., cycling, treadmill at moderate-high intensity)	Gait hypokinesia, postural instability, bradykinesia	Improvements in walking endurance, VO2 max, walking economy	Moderate	Schenkman et al. (2018) [7]; Penko et al. (2021) [8]
Resistance/Strength Training	Bradykinesia, rigidity, balance instability	Muscle strength, functional performance, gait speed	Moderate	Radder et al. (2020) [9]; Osborne et al. (2022) [10]
Balance & Gait Training (e.g., dual-task, strategy training)	Postural instability, FOG, gait disturbances	Improvements in functional mobility measures, Functional Reach Test (+2.16 cm), FOG Questionnaire (-1.41 points)	Moderate-High	Tomlinson et al. (2012) [6]
Cueing Strategies (e.g., auditory/visual cues, metronome)	FOG, gait hypokinesia	Step length, turning speed, freezing episodes	Moderate	Keus et al. (2021) [11]
Dance/Music-Based Movement (e.g., tango, Nordic walking)	Gait disturbances, balance instability, bradykinesia	Gait velocity, balance (TUG test), motor symptoms (UPDRS-III)	Low-Moderate	Solla et al. (2019) [12];
Martial Arts/Tai Chi/Qigong	Postural instability, bradykinesia, rigidity	Balance (BBS), gait speed, UPDRS motor score	Moderate	Tomlinson et al. (2012) [6]
Hydrotherapy/Aquatic Therapy	Balance instability, gait	Balance outcomes, physical capacity	Low	Mak et al. (2020) [13]
Exergaming/Virtual Reality	Gait disturbances, balance	Coordination, gait speed, postural control	Low-Moderate	Cikajlo et al. (2021) [14]
LSVT BIG/PD Warrior (amplitude-focused training)	Bradykinesia, hypokinesia, FOG	Postural control, motor outcomes, quality of life (PDQ-39)	Moderate	Iwai et al. (2024) [15]; Osborne et al. (2022) [10]

Home-Based/Remote Programs	All (personalized)	Adherence, long-term motor function	Moderate	van der Kolk et al. (2019) [16]; Duncan et al. (2023) [17]

Notes: UPDRS, Unified Parkinson's Disease Rating Scale; TUG, Timed Up & Go; BBS, Berg Balance Scale; FOG, Freezing of Gait. The evidence levels reflect the assessments from the included systematic reviews. Most studies reported short-term outcomes with limited long-term follow-up.

3.4. Key Movement Disorders and Targeted Interventions

3.4.1. Bradykinesia Management

Bradykinesia, characterized by slowness and reduced amplitude of movement, represents one of the most debilitating symptoms of PD. Progressive resistance training (PRT) has been shown to be effective in addressing this symptom. Systematic reviews of progressive resistance training studies indicate that PRT interventions, typically performed twice weekly, can reduce bradykinesia symptoms and improve functional performance. The intervention improved walking speed, sit-to-stand performance, and overall motor function, while enhancing muscle activation patterns. [1,18]

Systematic reviews suggest that effective PRT protocols typically involve moderate-to high-intensity training performed 2-3 days per week, with a focus on major muscle groups.

3.4.2. Freezing of Gait Interventions

Freezing of gait (FOG) affects up to 80% of individuals with advanced PD and significantly increases the risk of falls. Meta-analyses of freezing of gait interventions indicate that targeted exercise interventions show moderate effectiveness compared to control conditions in reducing subjective FOG severity. Importantly, the analysis distinguished between generic exercises and targeted interventions, finding that dedicated FOG-specific training was more effective than general exercise. [19]

The most effective FOG interventions include obstacle training (showing the greatest immediate positive effect), treadmill gait training, action observation training, visual and auditory cueing strategies, and conventional physiotherapy. [20,21]

Cueing strategies are powerful tools for FOG management. External cues, such as visual (floor markers), auditory (metronome beats), or tactile (vibrotactile devices), help bypass dysfunctional basal ganglia circuits by engaging alternative neural pathways through the frontal cortex. Research has demonstrated that cueing interventions can reduce FOG severity and improve gait parameters immediately after training. [22]

3.4.3. Postural Instability and Balance Training

Postural instability is a significant concern in mid-to-late stage PD, contributing to an increased fall risk and functional decline. A systematic review of balance interventions found that multifactorial physiotherapy approaches combining muscle strengthening, range of motion exercises, balance training, and walking exercises demonstrated superior outcomes compared to single-modality interventions. [3]

- Evidence-based balance interventions include the following:
- Highly challenging balance training (HiBT) incorporating dual-task components
- Technology-assisted balance training using force plates and visual feedback
- Dynamic balance exercises targeting both feedforward and feedback postural control
- Incremental speed-dependent treadmill training

The meta-analysis results indicated significant improvements in the Berg Balance Scale scores (SMD 0.23; 95% CI 0.10-0.36) following structured balance training programs. The most effective interventions specifically targeting balance dysfunction components demonstrated large effect sizes (SMD 5.98; 95% CI 2.29-9.66). [4]

3.5. Gait Rehabilitation Strategies

Gait impairments in PD include reduced step length, decreased walking speed, increased gait variability, and festination. Multiple systematic reviews have confirmed the effectiveness of various gait training approaches, with treadmill training showing consistent benefits across studies. [23,24] Systematic reviews of treadmill training have reported improvements in gait speed, stride length, and walking endurance across multiple studies.

The specificity of training effects is particularly notable; walking-based interventions improve walking parameters, whereas cycling-based aerobic exercise improves cardiovascular fitness but shows limited gait benefits. High-intensity aerobic training (80-85% maximum heart rate) demonstrates superior outcomes compared to moderate-intensity programs, particularly in early-stage PD. [25,26]

3.6. Innovative Physiotherapy Approaches

3.6.1. Dance and Movement Therapies

Dance therapy has gained substantial evidence as an effective intervention for multiple movement disorders in patients with PD. Studies examining various dance forms, including Argentine tango, contemporary dance, ballet, and Irish step dancing, have consistently demonstrated improvements in motor function, balance, and quality of life. [27,28]

- A recent systematic analysis found that dance interventions significantly improve
- Overall cognition (Montreal Cognitive Assessment scores: median improvement from 19.00 to 22.00)
- Quality of life (PDQ-39 scores: median improvement from 59.50 to 30.00)
- Balance and walking parameters
- Psychosocial health and social integration

The multidimensional approach of dance therapy addresses motor symptoms while simultaneously providing cognitive stimulation, emotional expression, and social interaction, factors that contribute to its comprehensive therapeutic benefits.

3.6.2. Virtual Reality and Exergaming

Emerging technologies have introduced new possibilities in PD rehabilitation. Virtual reality (VR) interventions have shown promise for gait and balance training by providing safe, controlled environments for skill practice with immediate feedback. [29-31]

Key findings from VR research include the following:

- Improved step and stride length compared to conventional physiotherapy
- Enhanced balance outcomes with technology-assisted training
- Superior gait performance with VR systems designed for specific PD impairments
- High patient satisfaction and motivation levels

Exergaming platforms, including Nintendo Wii and Microsoft Kinect systems, are effective and comparable to traditional balance training while offering enhanced motivation and potential for home-based therapy. A systematic review of 64 publications confirmed the safety, feasibility, and effectiveness of exergaming interventions, with clinical trials showing better or similar results compared with traditional rehabilitation. [32]

3.7. Aquatic Therapy

Hydrotherapy leverages the unique properties of water, including buoyancy, viscosity, and hydrostatic pressure, to facilitate therapeutic exercise in a supportive environment. The buoyant force reduces the gravitational stress on joints and muscles, which is particularly beneficial for individuals experiencing rigidity and postural instability. [33]

The benefits of aquatic therapy include:

- Significant improvements in postural stability
- Enhanced gait parameters including stride length and walking speed
- Reduced muscle rigidity and improved flexibility
- Superior mobility outcomes compared to land-based exercises (TUG test: -1.5 seconds improvement)

Specific aquatic methods that have shown effectiveness include Ai Chi (incorporating Tai Chi principles), the Halliwick Concept (focusing on rotational movements), and aquatic treadmill training.

3.8. Multimodal and Integrated Approaches

Current evidence strongly supports multimodal intervention approaches that combine different physiotherapeutic techniques. The most comprehensive meta-analysis to date, including 191 trials with 7,998 participants, found that conventional physiotherapy significantly improved motor symptoms, gait, and quality of life when multiple therapeutic elements were incorporated. [9,10,34]

Effective multimodal combinations include the following:

- Conventional physiotherapy + resistance training for enhanced functional outcomes [10]
- Balance training + muscle strengthening + range of motion exercises [3]
- Cueing strategies + task-specific gait training [20,22]
- Aerobic exercise + cognitive training + balance work [24]

The European Physiotherapy Guidelines for Parkinson's Disease provide standardized recommendations for implementing multimodal approaches in clinical practice. [35,9]

3.9. Dosage and Prescription Parameters

The included systematic reviews reported various intervention parameters, with the most effective programs involving regular sessions (2-4 times per week) of moderate to high intensity, delivered over 6-12 week periods.

Resistance Training:

- Frequency: 2-3 days per week
- Intensity: 60% of one-repetition maximum
- Sets/repetitions: 3 sets of 10 repetitions
- Duration: 8-10 weeks minimum [36]
- Balance Training:
- Frequency: 2-3 sessions per week
- Duration: 6-12 weeks
- Components: Static, dynamic, and functional balance exercises
- Progression: Gradually increase task complexity and challenge [4]

4. Discussion

4.1. Summary of Key Findings

This scoping review synthesized evidence from 15 high-level sources, encompassing 7,998 participants, and mapped 12 categories of physiotherapy interventions targeting specific movement disorders in Parkinson’s disease. The strongest evidence supports progressive resistance training for bradykinesia, treadmill training for gait dysfunction, and cueing strategies for freezing of gait, all of which demonstrate moderate-to-high quality evidence and clinically meaningful improvements. Balance training, Tai Chi, dance therapy, virtual reality, and aquatic therapy provided additional benefits for mobility, postural control, and quality of life, although the evidence quality varied from low to moderate. Most interventions were short-term (≤6 months), with limited evidence of sustained benefits.

4.2. Comparison with Existing Literature

Our findings align with the European Physiotherapy Guidelines for Parkinson’s Disease and recommendations from the American Physical Therapy Association, which emphasize early, individualized, and high-intensity physiotherapy to optimize motor outcomes. Consistent with prior meta-analyses, treadmill and resistance training improved gait speed and motor performance, reinforcing their role as first-line physiotherapy approaches in PD. Novel therapies, such as dance and virtual reality interventions, have shown promising results, echoing earlier reports of their ability to combine motor, cognitive, and psychosocial benefits. However, few studies have directly compared these innovative methods with conventional approaches, limiting conclusions about their relative efficacy.

4.3. Clinical Implications

This review highlights that disorder-specific physiotherapy interventions yield superior outcomes compared with generic programs. Clinicians should consider the following:

- Incorporating resistance training and amplitude-based exercises for bradykinesia management.
- Using cueing and treadmill-based training for freezing of gait and gait hypokinesia.
- Implementing balance-specific programs and Tai Chi to reduce fall risk.
- Exploring dance and virtual reality–based interventions to enhance motivation, adherence, and social participation.

The optimal delivery parameters include moderate-to-high intensity, 2–3 sessions per week, 30–60 min per session, and over 8–24 weeks. Personalization according to disease stage and symptom profile is critical for maximizing outcomes.

4.4. Research Gaps and Future Directions

This review highlights several areas where further investigation is needed to optimize physiotherapy interventions for movement disorders in Parkinson's disease.

- **Long-term retention and sustainability:** Most studies reported only short- to medium-term outcomes (≤6 months). Further research is needed to evaluate whether these benefits persist for 12 months or longer.
- **Optimal sequencing and timing:** The most effective order and timing of physiotherapy approaches (e.g., resistance training before gait training or combined versus sequential programs) remain unclear.
- **Personalized intervention strategies:** Future studies should explore treatment matching based on individual symptom profiles, disease stage, and comorbidities to develop personalized rehabilitation algorithms.
- **Technology integration:** The role of wearable sensors, mobile applications, and tele-rehabilitation platforms in monitoring and delivering physiotherapy requires rigorous evaluation of feasibility, cost-effectiveness, and scalability.
- **Accessibility and home-based delivery:** Given the progressive nature of PD and the barriers to clinic-based care, home-based and hybrid intervention models should be further developed and tested.
- **Underexplored symptoms:** Tremor- and rigidity-specific physiotherapy protocols remain poorly studied and require targeted research.

Advanced rehabilitation methods and standardized protocols require refinement, particularly in older adults who may experience reduced intervention responsiveness. Moreover, direct head-to-head comparative trials between different physiotherapy modalities are scarce, limiting evidence-based guidance on the prioritization of treatment approaches.

4.5. Strengths and Limitations of the Review

The strengths of this review include the use of a systematic scoping methodology, inclusion of high-level evidence (systematic reviews and guidelines), and synthesis across multiple movement disorders. Limitations include the restriction to English-language studies, exclusion of primary RCTs not covered in reviews, and reliance on reported effect sizes without formal meta-analysis.

5. Conclusion

This scoping review demonstrates that physiotherapy offers substantial benefits in the targeted management of movement disorders in patients with Parkinson's disease. Strong evidence supports progressive resistance training for bradykinesia, treadmill training for gait dysfunction, and cueing strategies for freezing of gait, while balance training, Tai Chi, dance, aquatic therapy, and virtual reality provide additional benefits across the motor and quality-of-life domains. Disorder-specific programs consistently outperform generic physiotherapy, highlighting the importance of tailoring interventions to symptom profiles and disease stages.

Optimal delivery involves moderate-to-high intensity exercise performed two to three times per week for 30–60 min over 8–24 weeks, supported by adherence strategies such as group formats and technology integration. However, the long-term efficacy, comparative effectiveness, and interventions for rigidity and tremor remain underexplored, and further research is needed to establish personalized, scalable, and technology-enabled care models.

Physiotherapy should be regarded as a core component of Parkinson's disease management. By advancing disorder-specific, evidence-based, and accessible approaches, clinicians can optimize the mobility, independence, and quality of life of individuals living with Parkinson's disease.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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