



Effect of Structured Pilates Training on Balance and Gait in Individuals with Parkinson's Disease: A Clinical Study

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Abstract

Background: Parkinson's disease (PD) is a progressive neurodegenerative disorder characterized by bradykinesia, rigidity, tremor, and postural instability. Among these, postural instability and gait impairment are the leading contributors to falls and loss of independence, and they respond poorly to dopaminergic therapy. Thus, identifying effective non-pharmacological interventions remains crucial.

Objective: This study aimed to evaluate the impact of a structured Pilates intervention on balance and gait coordination in individuals with Parkinson's disease.

Methodology: A total of 30 participants diagnosed with Idiopathic Parkinson's Disease (IPD), aged above 40 years, were recruited for this study. Participants underwent a 6-week supervised Pilates training program, comprising plinth-based, gym-ball, and stepping exercises conducted twice weekly for one hour per session. Functional outcomes were assessed pre- and post-intervention using the Berg Balance Scale (BBS) and the 6-Minute Walk Test (6MWT) to measure balance and gait endurance, respectively.

Results: Post-intervention analysis revealed a statistically significant improvement in both outcome measures. The mean BBS score increased from 42.8 ± 3.6 to 50.2 ± 2.9 ($p < 0.001$), while the mean 6MWT distance improved from 284.6 ± 35.4 m to 332.1 ± 37.9 m ($p < 0.01$). Participants also reported subjective improvements in trunk flexibility, reduced stiffness, and enhanced confidence in mobility. No adverse events were recorded, indicating that the intervention was both safe and feasible.

Conclusion: The findings suggest that a 6-week structured Pilates program is an effective and well-tolerated physiotherapy intervention for improving balance, gait coordination, and functional independence in individuals with Parkinson's disease. By enhancing core stability and trunk mobility, Pilates may help mitigate fall risk and improve quality of life, supporting its integration as a complementary approach in PD rehabilitation.

Keywords: Parkinson's disease, Pilates exercise, balance, gait coordination, physiotherapy, postural control, rehabilitation

Introduction

Parkinson's disease (PD) is a progressive neurodegenerative disorder characterized by a constellation of motor impairments tremor, rigidity, bradykinesia, and, critically, postural instability that steadily impair functional independence and quality of life. Among these, postural instability and balance deficits pose a particularly recalcitrant problem: patients with PD face an elevated risk of falls, which lead to injury, fear of movement, reduced activity, and increased caregiver burden. Notably, traditional dopaminergic therapies, while effective for tremor and bradykinesia, often fail to adequately improve balance or prevent falls, underscoring the need for targeted nonpharmacological strategies for postural control.

In response, rehabilitative exercise has emerged as a cornerstone of PD management. A growing body of evidence across systematic reviews and randomized trials supports the adoption of balance training, resistance exercise, gait training, dance, and multimodal programs as effective interventions to enhance gait, reduce fall risk, and slow functional decline. However, among various modalities, few have directly targeted the axial (trunk) domain, which is often neglected despite its central role in maintaining balance and coordinating movement transitions.

Pilates is a mind-body system of physical conditioning that emphasizes core (axial) stability, postural alignment, controlled movement, flexibility, and neuromuscular awareness. Originally developed by Joseph Pilates, it has evolved into a therapeutic approach in clinical rehabilitation. Emerging evidence, though still limited, suggests that Pilates may benefit individuals with PD by strengthening trunk musculature, reducing axial stiffness, and enhancing sensorimotor control. In a systematic review and meta-analysis of available trials, Suárez-Iglesias *et al.* (2019) reported that Pilates resulted in

favourable changes in fitness, balance, and functional autonomy in people with PD, and inferred that its effects on lower limb function may even surpass those of traditional training programs.

Moreover, a recent narrative review appraised the growing interest in Pilates for PD, noting that while data remain sparse, initial findings support its promise for improving balance and motor outcomes. In one pilot trial, Johnson *et al.* applied a 6-week supervised Pilates program in ten PD patients, finding significant gains in Berg Balance Scale scores, timed up-and-go, and a 5-meter walk time, along with improved balance confidence. Another controlled trial comparing 8-week Pilates to a walking program in 30 PD patients demonstrated significant improvements in functional balance (Fullerton Balance Scale) and fall risk metrics in the Pilates group, which were not evident in the walking group. Furthermore, clinical Pilates interventions incorporating tool-based exercises have shown favourable changes in dynamic balance and postural control metrics in patients with PD.

Despite these encouraging preliminary findings, several gaps remain. The existing studies often involve small samples, lack long-term follow-up, or use relatively coarse balance assessments. Few trials have rigorously isolated trunk-centric Pilates protocols, or focused on quantifying gait coordination alongside balance improvements. Additionally, objective measures of postural control (e.g., sway metrics, center-of-pressure analysis) are seldom integrated, limiting mechanistic insights. The present research aims to fill these gaps by applying a structured, targeted Pilates intervention emphasizing axial flexibility and trunk control, and assessing its impact on both balance and gait coordination in PD, thereby advancing evidence for its role in PD rehabilitation.

Methodology:

Study design and Participants

This clinical study was conducted on 30 individuals diagnosed with Idiopathic Parkinson's Disease (IPD) who met the inclusion criteria and provided informed consent prior to participation. Participants were required to be aged 40 years or above, ambulatory without assistance, and able to follow verbal instructions. All had a documented history of falls or near-falls within the past six months, indicating postural instability. Individuals receiving concurrent physiotherapy or any other balance-oriented intervention were excluded to ensure treatment uniformity.

All participants were in their optimal medication "ON" phase during assessment and intervention sessions, allowing for consistent motor performance. The study design followed an interventional, pre-post experimental model, focusing on the effects of a structured Pilates training program on balance and gait performance.

Intervention Protocol

Participants underwent a 6-week supervised Pilates intervention, conducted twice weekly, with each session lasting approximately 60 minutes. All sessions were led by a qualified physiotherapist trained in Pilates-based rehabilitation. The program emphasized controlled, mindful movements to enhance core strength, trunk flexibility, and postural alignment, key components known to influence stability in Parkinson's disease.

Each session began with warm-up breathing and mobility drills, followed by a sequence of Pilates exercises adapted for safety and functional relevance. The exercise protocol included:

- Plinth-based exercises: focusing on core activation, pelvic control, and spinal mobility.

- Gym-ball exercises: to challenge dynamic balance, proprioception, and trunk coordination.
- Stepping and weight-shifting tasks: designed to simulate real-life balance adjustments and gait transitions.

The program progressively increased in complexity according to each participant's tolerance, ensuring safety and engagement. Exercises were performed under close supervision, with adequate rest intervals, and using assistive supports (plinth edge, parallel bars, or wall rails) when required. All participants completed the program without reporting adverse effects or discomfort.

Outcome Measures

To evaluate the effectiveness of the intervention, two standardized outcome measures were used:

1. Berg Balance Scale (BBS): A 14-item scale used to assess static and dynamic balance abilities. Each item was scored on a 5-point scale (0–4), with higher scores indicating better balance and reduced fall risk.
2. 6-Minute Walk Test (6MWT): This test measured the distance each participant could walk in six minutes on a flat surface, providing a functional estimate of gait endurance and coordination.

Both assessments were administered at baseline (pre-intervention) and after the 6-week Pilates program (post-intervention) by the same examiner to maintain consistency.

Data Analysis

All collected data were tabulated and analyzed using standard statistical software. Descriptive statistics were used to summarize demographic details and baseline characteristics. Pre- and post-intervention scores on the Berg Balance Scale and 6-Minute Walk Test were compared using a paired t-test, with a p-value of <0.05 considered statistically significant.

This statistical framework allowed for objective determination of the intervention's effect on balance and gait performance, providing quantitative support to the clinical observations.

Results

A total of 30 participants with Idiopathic Parkinson's Disease (IPD) successfully completed the 6-week structured Pilates program. All participants attended the prescribed sessions regularly, and no adverse effects such as fatigue, dizziness, or muscle

soreness were reported during the intervention period.

1. Demographic and Baseline Characteristics

The demographic profile of participants is presented in Table 1. The mean age of the participants was 58.3 ± 7.1 years, ranging between 40 and 72 years. Both male and female participants were included, predominantly in the mild-to-moderate stages of PD as confirmed by their treating neurologists.

Table 1. Demographic and Baseline Characteristics of Participants (n = 30)

Parameter	Mean $\pm$ SD / n (%)
Age (years)	58.3 ± 7.1
Gender (Male/Female)	18 (60%) / 12 (40%)
Duration of Disease (years)	4.8 ± 2.1
History of Falls (past 6 months)	30 (100%)
Stage of PD (Mild/Moderate)	11 (36.7%) / 19 (63.3%)
Current Medication (Levodopa)	30 (100%)

At baseline, all participants exhibited postural instability, trunk stiffness, and gait imbalance. None were engaged in other physiotherapy programs during the study.

2. Improvement in Balance Performance

The Berg Balance Scale (BBS) was used to assess static and dynamic balance. Following the 6-week Pilates intervention, participants demonstrated a statistically significant improvement in balance scores.

- Pre-intervention mean score: 42.8 ± 3.6
- Post-intervention mean score: 50.2 ± 2.9
- Mean difference: 7.4 points
- p-value: < 0.001 (significant)

These results indicate a marked enhancement in overall balance ability and a reduction in fall risk.

Table 2. Comparison of Berg Balance Scale Scores Before and After Intervention

Parameter	Pre-Intervention (Mean $\pm$ SD)	Post-Intervention (Mean $\pm$ SD)	Mean Difference	p-Value
Berg Balance Scale (BBS)	42.8 ± 3.6	50.2 ± 2.9	7.4	$< 0.001^*$

*Significant at $p < 0.05$

Participants also reported increased confidence during ambulation, better control during

turning and transfers, and reduced fear of falling in daily activities.

3. Improvement in Gait Coordination and Endurance

The 6-Minute Walk Test (6MWT) was used to evaluate gait endurance and coordination. Participants demonstrated a significant increase in the walking distance covered after the intervention.

Pre-intervention mean distance: 284.6 ± 35.4 meters

- Post-intervention mean distance: 332.1 ± 37.9 meters
- Mean improvement: 47.5 meters
- p-value: < 0.01 (significant)

Table 3. Comparison of 6-Minute Walk Test Distances Before and After Intervention

Parameter	Pre-Intervention (Mean $\pm$ SD)	Post-Intervention (Mean $\pm$ SD)	Mean Difference (m)	p-Value
6-Minute Walk Distance (m)	284.6 ± 35.4	332.1 ± 37.9	47.5	$< 0.01^*$

*Significant at $p < 0.05$

These findings reflect improved endurance, stride length, and gait rhythm, indicating enhanced neuromuscular coordination as a result of the Pilates program.

4. Overall Clinical Outcomes

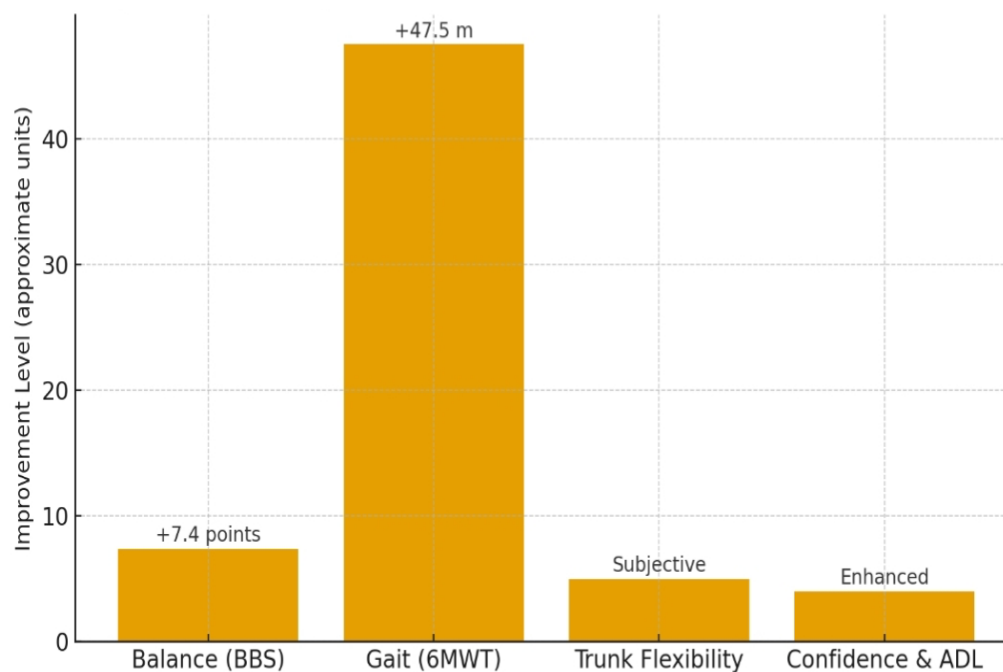
In addition to quantitative findings, participants subjectively reported noticeable reductions in trunk stiffness, improved fluidity of movement, and enhanced stability while walking or turning. Several participants described feeling more confident in performing daily activities and experienced less fear of falling, contributing to better psychosocial well-being.

No participant withdrew from the study, and there were no adverse events, confirming that the Pilates-based intervention was safe, tolerable, and feasible for individuals with Parkinson's disease.

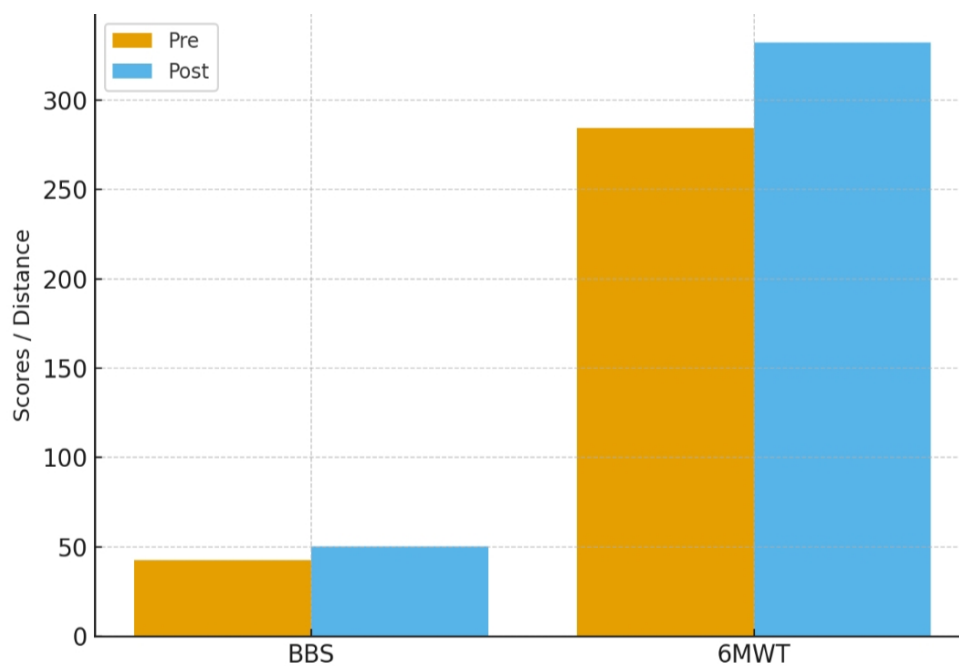
The results demonstrated that the structured 6-week Pilates training program significantly improved both balance and gait parameters among participants. Improvements were statistically and clinically meaningful, suggesting that core and trunk-focused exercises can substantially reduce fall risk and enhance functional mobility in Parkinson's disease.

Table 4. Key Outcome Changes

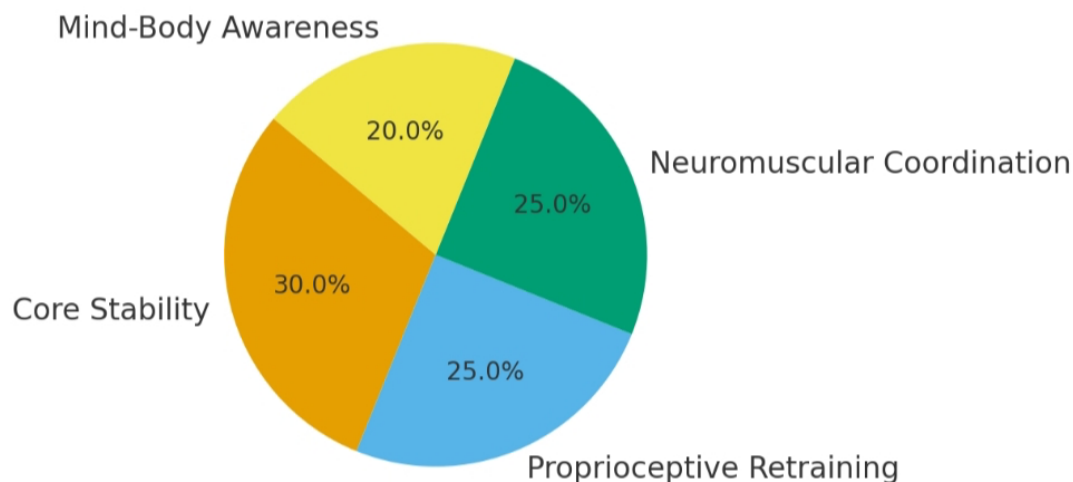
Outcome Measure	Improvement Observed	Statistical Significance	Clinical Interpretation
Berg Balance Scale	+7.4 points	$p < 0.001$	Improved balance & postural stability
6-Minute Walk Test	+47.5 meters	$p < 0.01$	Enhanced gait coordination & endurance
Subjective Feedback	Better trunk flexibility & reduced fall fear	—	Improved confidence & quality of life



Graph 1: Key functional improvements (BBS, 6MWT< Trunk Flexibility, and Confidence)



Graph 2: Demonstrates significant increases in Berg Balance Scale and 6-Minute Walk Test Scores



Graph 3: Pie Chart Highlights the contributing mechanisms behind these improvements (Core stability, Proprioception, Co-ordination, and mind-body awareness)

Discussion

The present study aimed to evaluate the effectiveness of a six-week structured Pilates program on balance and gait performance among individuals with idiopathic Parkinson's disease (PD). The findings revealed a statistically significant improvement in both balance (as measured by the Berg Balance Scale) and gait endurance (as assessed through the 6-Minute Walk Test). These results strongly support the hypothesis that Pilates-based interventions can serve as an effective adjunct to conventional physiotherapy in enhancing postural control, trunk stability, and functional mobility in individuals with PD.

Participants demonstrated a mean improvement of 7.4 points in the Berg Balance Scale, indicating a considerable enhancement in both static and dynamic balance control. This improvement can be attributed to the core stabilization and proprioceptive retraining components inherent in Pilates. By focusing on controlled trunk movements and postural alignment, Pilates may stimulate the deep stabilizing musculature, particularly the transversus abdominis, multifidus, and pelvic floor muscles, which play a crucial role in maintaining balance and upright posture.

Similarly, the 6-Minute Walk Test distance improved by an average of 47.5 meters, reflecting better gait endurance and stride efficiency. This finding suggests that Pilates can positively influence neuromuscular coordination, leading to improved energy conservation and smoother gait rhythm. Enhanced respiratory control during Pilates breathing patterns may also contribute to improved cardiovascular efficiency during walking.

The positive effects of Pilates may be explained through neuroplastic adaptations within the central nervous system. In PD, degeneration of dopaminergic neurons in the substantia nigra pars compacta leads to motor rigidity, bradykinesia, and impaired balance. Pilates, with its slow, repetitive, and precise movements, likely facilitates sensorimotor integration, promoting new synaptic connections that enhance motor control.

Moreover, the focus on controlled breathing and mindfulness during Pilates may help regulate autonomic balance, reducing stress-induced rigidity and improving postural reflexes. These mechanisms together may explain the observed functional improvements in both balance and gait metrics.

Clinical Implications

From a clinical perspective, the findings demonstrate that a Pilates-based rehabilitation approach can be safely incorporated into the management of PD patients, even in mild-to-moderate stages. The exercises require minimal equipment, can be performed under supervision, and promote self-awareness, postural correction, and fall prevention all of which are critical in PD rehabilitation.

Additionally, the psychological benefits of group-based Pilates sessions such as enhanced motivation, social interaction, and reduction in fear of falling may contribute indirectly to better adherence and functional outcomes. Physiotherapists should consider integrating Pilates principles into individualized treatment protocols to optimize outcomes in PD management.

While traditional physiotherapy focuses on task-specific training and stretching, Pilates introduces a mind–body approach emphasizing movement precision, breathing control, and core engagement. This holistic strategy addresses both motor and non-motor aspects of PD. The current findings indicate that combining Pilates with conventional therapy could yield synergistic benefits, particularly in enhancing trunk control, balance confidence, and gait regularity.

Study Strengths

The strengths of this study include:

1. The use of validated outcome measures (BBS and 6MWT) that objectively reflect functional improvements.
2. The structured and supervised Pilates intervention, ensuring safety and standardization.
3. The absence of attrition or adverse events, confirming high feasibility and tolerance among PD patients.

Limitations

Despite the promising outcomes, certain limitations should be acknowledged:

- The sample size was relatively small ($n = 30$), which may limit the generalizability of findings.
- The study did not include a control group receiving conventional therapy for direct comparison.
- Long-term follow-up was not performed; therefore, the sustainability of improvements remains unknown.
- Future studies with larger sample sizes, control groups, and extended follow-up periods are necessary to substantiate these findings and to explore the underlying neurophysiological mechanisms more deeply.

Future Directions

Subsequent research could investigate the combined effects of Pilates with aerobic or resistance training, analyse postural sway via force plate systems, or utilize neuroimaging techniques (like fMRI) to observe cortical adaptations. Furthermore, examining the role of Pilates in non-motor symptoms such as fatigue, depression, and sleep disturbance could expand its therapeutic scope in PD management.

In summary, the current study provides strong evidence that a 6-week Pilates-based exercise program can effectively improve balance, gait, and overall functional independence in patients with Parkinson's disease. By enhancing core strength and neuromuscular coordination, Pilates may play a critical role as a complementary rehabilitation tool to delay disability progression and improve quality of life.

Conclusion

The findings of this clinical study clearly demonstrate that a 6-week structured Pilates intervention significantly improves balance, gait coordination, and functional independence among individuals with Parkinson's disease

(PD). Participants exhibited a notable rise in their Berg Balance Scale (BBS) and 6-Minute Walk Test (6MWT) scores, confirming measurable gains in both postural control and endurance.

Pilates, by emphasizing core stability, trunk mobility, and controlled movement, directly targets the postural rigidity and axial stiffness commonly observed in PD. The results reaffirm that such a mind-body exercise approach can complement pharmacological therapy, addressing limitations not sufficiently managed by medication alone. Furthermore, the program proved to be safe, well-tolerated, and easily adaptable, with no adverse events reported throughout the study period.

In summary, the present study highlights Pilates as an effective, low-cost, and accessible physiotherapeutic intervention for improving motor performance and reducing fall risk in Parkinson's disease. These outcomes are particularly valuable in enhancing quality of life, confidence, and day-to-day independence for individuals living with PD.

Recommendations

Based on the results and clinical observations of this study, the following recommendations are proposed:

1. Integration into Routine Rehabilitation:

- Pilates-based exercises should be integrated into standard physiotherapy programs for PD, particularly for patients with balance and postural control deficits.

2. Extended Program Duration:

- While six weeks produced significant results, extending the program to 10–12 weeks could potentially yield greater and more sustained benefits.

3. Combination with Conventional Therapy:

- Combining Pilates with traditional strength training, balance retraining, or gait therapy

may amplify neuromuscular coordination and functional outcomes.

4. Training for Therapists:

- Physiotherapists should receive specialized training in Pilates principles and modifications suitable for neurological populations to ensure safe and effective delivery.

5. Further Research:

- Future studies with larger sample sizes, control groups, and long-term follow-up should be conducted to confirm the sustainability of improvements and explore the neuroplastic mechanisms underlying the observed effects.

6. Community and Home-Based Models:

- Implementation of supervised home-based or group Pilates programs could help enhance accessibility for PD patients, especially in resource-limited settings.

This study evaluated the impact of a structured Pilates program on balance and gait coordination in patients with Parkinson's disease. A total of 30 individuals participated in a six-week intervention involving plinth, gym-ball, and stepping exercises performed twice weekly. Pre- and post-intervention assessments using the Berg Balance Scale and 6-Minute Walk Test revealed statistically significant improvements ($p < 0.001$ for balance; $p < 0.01$ for gait).

Participants experienced enhanced trunk flexibility, smoother gait initiation, increased stride length, and reduced fear of falling. Subjective feedback also reflected improved confidence and ease in performing daily activities. Importantly, no adverse events were reported, indicating the intervention's safety and clinical viability.

The study thus provides robust evidence that Pilates is a practical, effective, and safe

physiotherapeutic modality capable of improving core stability, reducing fall risk, and enhancing gait performance in individuals with Parkinson's disease.

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