ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/26jun1595

Effectiveness of Endurance Exercise Training to Improve Economy of Movement in People with Parkinson Disease: A Case Report

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Publication Date: 2026/07/24

Abstract:

- ***Background:***

Parkinson disease (PD) is a progressive neurodegenerative disorder characterized by motor impairments including bradykinesia, rigidity, tremor, and postural instability. These impairments negatively affect gait efficiency and increase the energy cost of movement, leading to early fatigue and reduced participation in daily activities. Impaired economy of movement is a significant contributor to functional decline in people with PD. Endurance exercise training has been shown to improve cardiovascular fitness and neuromuscular efficiency in various neurological and musculoskeletal conditions. However, limited case-based evidence is available regarding its specific effects on movement economy in individuals with Parkinson disease.

- ***Objective:***

The objective of this case report was to evaluate the effects of a structured endurance exercise training program on economy of movement, gait efficiency, and functional mobility in a person with Parkinson disease.

- ***Case Presentation:***

The case involved a 62-year-old individual diagnosed with idiopathic Parkinson disease at Hoehn and Yahr stage II. The participant underwent an eight-week endurance exercise training program consisting of moderate-intensity aerobic activities, including treadmill walking and stationary cycling, performed four times per week. Exercise intensity was prescribed using heart rate reserve and the Borg Rating of Perceived Exertion scale. Outcome measures included economy of movement assessed by oxygen consumption during submaximal walking, gait parameters, walking endurance, and self-reported fatigue. Assessments were conducted at baseline and following completion of the intervention.

- ***Results:***

Following the endurance training program, the participant demonstrated improved economy of movement, indicated by reduced oxygen consumption at equivalent walking speeds. Improvements were also observed in gait efficiency, walking endurance, and functional mobility. The participant reported decreased fatigue during daily activities. No adverse events or exercise related complications were reported.

- ***Conclusion:***

This case report suggests that endurance exercise training may be a safe and effective intervention for improving economy of movement and functional performance in individuals with Parkinson disease. Larger studies are warranted to confirm these findings and guide clinical practice.

Keywords: *Parkinson Disease; Endurance Exercise; Economy of Movement; Case Report; Gait Efficiency*

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How to Cite: Dr. Soumi Das; Dr. S. K. Samidul Islam; Dr. Saptarshi Mondal (2026). Effectiveness of Endurance Exercise Training to Improve Economy of Movement in People with Parkinson Disease: A Case Report. *International Journal of Innovative Science and Research Technology*, (ICVDRS–2026), 47-52. https://doi.org/10.38124/ijisrt/26jun1595

I. INTRODUCTION

Parkinson disease (PD) is a progressive neurodegenerative disorder characterized by the degeneration of dopaminergic neurons in the substantia nigra, resulting in a wide range of motor and non-motor impairments. It is the second most common neurodegenerative condition worldwide and predominantly affects older adults, with prevalence increasing with age. The cardinal motor features of PD include bradykinesia, rigidity, resting tremor, and postural instability, all of which significantly impair movement control and functional mobility. As the disease progresses, these motor impairments increasingly interfere with an individual’s ability to perform daily activities and maintain independence.

One of the less frequently emphasized but clinically important consequences of Parkinson disease is impaired economy of movement. Economy of movement refers to the amount of metabolic energy required to perform a given physical task, such as walking, at a standardized workload. Individuals with PD often exhibit higher oxygen consumption during walking and other functional activities compared to age-matched healthy individuals, indicating reduced movement efficiency. Factors such as muscle rigidity, altered motor unit recruitment, reduced stride length, impaired coordination, and postural instability contribute to this increased energy cost. Poor movement economy leads to early onset of fatigue, reduced endurance, decreased participation in physical activity, and diminished quality of life.

Fatigue is one of the most disabling non-motor symptoms reported by individuals with PD and is strongly associated with reduced functional capacity and psychosocial well-being. Increased metabolic demand during routine tasks exacerbates fatigue and may discourage engagement in physical activity, thereby accelerating functional decline. Consequently, interventions that reduce the energy cost of movement have the potential to improve both physical performance and overall participation in daily life for people with Parkinson disease.

Exercise has emerged as a cornerstone of contemporary Parkinson disease management. A growing body of evidence supports the role of structured exercise programs in improving motor symptoms, gait performance, balance, cardiovascular fitness, and quality of life in individuals with PD. Aerobic and endurance exercise training, in particular, has been shown to enhance cardiorespiratory capacity, improve neural efficiency, and promote exercise-induced neuroplasticity. These adaptations may lead to more efficient motor control and reduced metabolic cost during functional tasks such as walking.

Endurance exercise training involves sustained, rhythmic physical activity performed at moderate to vigorous intensity, typically targeting improvements in cardiovascular and muscular endurance. In neurological populations, endurance training has been associated with improved oxygen uptake kinetics, enhanced mitochondrial efficiency, and better integration of motor and sensory systems. In individuals with PD, these physiological adaptations may help counteract bradykinesia, improve gait rhythm, and optimize muscle activation patterns, thereby improving economy of movement.

Despite increasing evidence supporting the benefits of aerobic and endurance exercise in Parkinson disease, relatively few studies have specifically examined changes in movement economy as a primary outcome. Most existing research focuses on improvements in gait speed, balance, or motor symptom severity, with limited attention given to the metabolic efficiency underlying these functional gains. Furthermore, there is a lack of detailed case-based evidence describing individual responses to endurance training interventions, particularly in relation to oxygen consumption and fatigue during submaximal functional tasks.

Case reports play an important role in rehabilitation research by providing detailed clinical insights, documenting feasibility and safety, and highlighting individualized responses to therapeutic interventions. Such evidence is especially valuable in chronic, heterogeneous conditions like Parkinson disease, where disease presentation and response to exercise can vary widely among individuals.

Therefore, the purpose of this case report is to examine the effects of a structured endurance exercise training program on economy of movement, gait efficiency, functional mobility, and fatigue in an individual with idiopathic Parkinson disease. By documenting changes in oxygen consumption during walking and related functional outcomes, this report aims to contribute to the growing evidence supporting endurance exercise as a meaningful component of Parkinson disease rehabilitation.

II. CASE PRESENTATION

➢ *Participant Profile*

The participant was a 62-year-old male diagnosed with idiopathic Parkinson disease 4 years prior and classified as Hoehn and Yahr Stage II, indicating mild bilateral symptoms without significant gait impairment at rest (Hoehn & Yahr, 1967). The individual reported increasing fatigue during daily activities and reduced walking endurance over the past year. He was ambulatory without assistive devices and maintained regular pharmacologic management including a stable dose of levodopa-carbidopa. The participant provided written informed consent to participate in the exercise intervention and publication of findings.

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➢ *Baseline Assessment*

Baseline assessments were completed one week before initiation of the endurance training program. Assessments included:

- Economy of Movement: Measured by oxygen consumption (VO_2) using a metabolic cart during a standardized submaximal treadmill walking task at 2.0 km/h.
- Gait Efficiency: Assessed via spatiotemporal gait parameters using a validated pressuresensitive walkway (e.g., GAITRite®) to measure stride length, cadence, and walking speed.
- Functional Mobility: Evaluated using the 6-Minute Walk Test (6MWT) and Timed Up and Go (TUG).
- Self-Reported Fatigue: Measured using the Parkinson Fatigue Scale (PFS-16), a PDspecific validated questionnaire.
- Safety and Tolerance: Monitored via weekly check-ins and symptom logs.

At baseline, the participant demonstrated elevated VO_2 values (indicative of inefficient movement economy), reduced gait speed, and increased self-reported fatigue, consistent with prior literature on movement inefficiency in PD (Christofoletti et al., 2006).

III. METHODOLOGY

➢ *Intervention Protocol*

The endurance training program consisted of supervised aerobic exercise sessions conducted three to five times per week over eight weeks. Sessions included:

- Treadmill Walking: 20–30 minutes per session at moderate intensity (60–75% of heart rate reserve).
- Stationary Cycling: 15–25 minutes per session on alternate days to reduce monotony and maintain engagement.
- Warm-Up/Cool-Down: 5 minutes each of light stretching and low-intensity walking.

Exercise intensity was prescribed using heart rate reserve (HRR) and the Borg Rating of Perceived Exertion (RPE) scale (6–20) to ensure moderate intensity (Borg, 1998). Weekly increments in duration (2–3 minutes) were included as tolerated. Attendance, heart rate responses, and RPE scores were recorded for each session.

➢ *Monitoring and Safety*

Weekly follow-ups were conducted via telephone or telehealth to reinforce adherence, monitor symptoms, and address any concerns. Participants were advised to report any musculoskeletal pain, cardiovascular symptoms, or exercise-related adverse events immediately. No serious adverse events were reported.

➢ *Post-Intervention Assessment*

Outcome measures identical to baseline assessments were repeated within one week of completing the eight-week intervention. Comparisons were made descriptively due to the singlesubject design, with attention to clinically meaningful changes.

IV. RESULTS

➢ *Adherence and Safety*

The participant completed 85% of scheduled sessions with no missed sessions due to adverse events. Moderate muscle soreness was reported during the first two weeks but resolved without intervention. No cardiovascular or neurological complications occurred.

➢ *Economy of Movement*

Post-training assessments demonstrated a notable reduction in VO_2 during submaximal treadmill walking at the same speed as baseline. Specifically, oxygen consumption decreased by approximately 12%, indicating improved movement economy and reduced metabolic demand for the given task.

➢ *Gait Efficiency*

Changes in gait parameters revealed:

- Increased Walking Speed: From 1.02 m/s at baseline to 1.15 m/s post-intervention.
- Improved Stride Length: Increased stride length by 8%.
- Cadence Adjustments: Slight increase in steps per minute, reflecting more efficient stepping patterns.

These changes align with prior findings that aerobic exercise can improve gait mechanics in PD (Petzinger et al., 2013).

➢ *Functional Mobility*

Functional outcomes improved across 6MWT and TUG:

- 6-Minute Walk Test: Distance increased by 45 meters (from 380 m to 425 m).
- Timed Up and Go: Time decreased from 10.2 seconds to 8.9 seconds.

Improvements exceed known minimal clinically important differences (MCIDs) for individuals with PD (Steffen & Seney, 2008).

➢ *Fatigue and Quality of Life*

Self-reported fatigue (PFS-16 score) decreased by 18%, indicating perceived improvements in energy levels and reduced activity-related exhaustion. The participant also reported subjective improvements in confidence during daily ambulation and less overall physical strain.

V. DISCUSSION

This case report examined the effects of an eight-week endurance exercise training program on economy of movement, gait efficiency, functional mobility, and fatigue in an individual with Parkinson disease. The findings indicate

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that structured moderate-intensity endurance training was associated with meaningful improvements in metabolic efficiency during walking, gait parameters, walking endurance, and perceived fatigue, without adverse events. These results support the growing body of evidence suggesting that endurance exercise plays a valuable role in Parkinson disease rehabilitation.

A key finding of this case was the improvement in economy of movement, as evidenced by reduced oxygen consumption during submaximal treadmill walking at a standardized speed. Individuals with Parkinson disease typically exhibit increased energy expenditure during gait due to factors such as bradykinesia, muscle rigidity, reduced stride length, and impaired motor coordination. These abnormalities lead to inefficient movement patterns and greater metabolic demand even during low-intensity activities. The observed reduction in oxygen cost following endurance training suggests enhanced neuromuscular efficiency, improved coordination, and better utilization of energy during walking. Improved economy of movement is clinically significant, as it may directly contribute to reduced fatigue and increased tolerance for daily physical activities.

The improvements observed in gait efficiency further support the positive effects of endurance training. Following the intervention, the participant demonstrated increased walking speed and stride length, accompanied by subtle improvements in cadence. These changes indicate a shift toward a more normalized gait pattern, which may reduce compensatory movements and unnecessary muscle activation. Previous research has shown that aerobic exercise can enhance gait mechanics in Parkinson disease by improving rhythmicity, motor timing, and postural control. Endurance training may also improve lower-limb muscle endurance and reduce co-contraction, contributing to smoother and more efficient gait.

Functional mobility outcomes, including the 6-Minute Walk Test and Timed Up and Go, showed clinically meaningful improvements following the intervention. The increase in walking distance during the 6-Minute Walk Test reflects enhanced endurance and cardiovascular capacity, while the reduction in Timed Up and Go time indicates improved functional mobility and transitional movements. These improvements suggest that endurance exercise benefits extend beyond metabolic efficiency to positively influence overall functional performance. Importantly, the magnitude of change exceeded reported minimal clinically important differences for individuals with Parkinson disease, highlighting the clinical relevance of the findings.

A notable outcome of this case was the reduction in self-reported fatigue following endurance training. Fatigue is a prevalent and debilitating symptom in Parkinson disease and is often exacerbated by poor movement economy and reduced physical conditioning. By improving cardiovascular fitness and reducing the metabolic cost of movement, endurance exercise may decrease perceived effort during daily tasks, thereby alleviating fatigue. Additionally, regular physical activity has been associated with improved mood, sleep quality, and self-efficacy, which may further contribute to reductions in fatigue and enhanced quality of life.

Several physiological mechanisms may explain the observed improvements. Endurance training is known to enhance cardiovascular efficiency, mitochondrial density, and oxygen delivery to working muscles. In Parkinson disease, exercise has also been shown to promote neuroplasticity through increased dopaminergic signaling, upregulation of neurotrophic factors, and improved corticomotor excitability. These adaptations may enhance motor unit recruitment, reduce rigidity, and improve motor planning, collectively leading to more efficient movement patterns. The combination of peripheral and central adaptations likely contributed to the improvements in economy of movement and functional performance observed in this case.

From a clinical perspective, this case demonstrates the feasibility and safety of moderateintensity endurance exercise for individuals with mild to moderate Parkinson disease. The high adherence rate and absence of serious adverse events suggest that endurance training can be successfully integrated into rehabilitation programs when appropriately prescribed and monitored. The use of heart rate reserve and perceived exertion to guide intensity allowed individualized progression while maintaining safety. Alternating treadmill walking and cycling helped maintain engagement and reduce the risk of overuse injuries.

Despite the encouraging findings, several limitations must be acknowledged. As a singlecase report, the results cannot be generalized to the broader Parkinson disease population. The absence of a control condition limits the ability to attribute improvements solely to the endurance training intervention, as factors such as medication effects or natural disease variability may have influenced outcomes. Additionally, long-term follow-up was not conducted, and therefore the sustainability of the observed improvements remains unknown. Future studies should include larger samples, control groups, and extended follow-up periods to confirm and expand upon these findings.

In summary, this case report provides preliminary evidence that endurance exercise training may improve economy of movement, gait efficiency, functional mobility, and fatigue in individuals with Parkinson disease. These findings underscore the importance of incorporating endurance-based interventions into comprehensive Parkinson disease rehabilitation programs and highlight the need for further research to establish optimal training parameters and long-term benefits.

VI. LIMITATIONS

As a single case, generalizability is limited. The absence of a control condition or multiple participants restricts causal inference. Other factors such as medication timing, daily activity levels, and psychosocial variables were not controlled and may influence outcomes.

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VII. CONCLUSION

This case report demonstrates that a structured endurance exercise training program can positively influence economy of movement, gait efficiency, functional mobility, and fatigue in an individual with Parkinson disease. Improvements in oxygen consumption during submaximal walking indicate enhanced movement efficiency, which may translate into reduced energy expenditure and improved tolerance for daily activities. Gains in gait parameters and functional mobility further suggest that endurance training supports meaningful improvements in overall motor performance. Although the findings are limited by the single-case design, they highlight the feasibility and safety of endurance exercise in Parkinson disease rehabilitation. Future research involving larger sample sizes, controlled study designs, and long-term follow-up is needed to confirm these preliminary findings and establish evidence-based guidelines for endurance training in this population.

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