



Article submitted to the "Emirates Journal of Internal Medicine"

[Internalmed.ae/journal/high-intensity-aerobic-exercise](http://Internalmed.ae/journal/high-intensity-aerobic-exercise)

## Subject Areas:

Neurology

## Keywords:

Parkinson's disease, Aerobic Exercise, Neurological Effects, High-Intensity Program, Quality of Life

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# High-Intensity Aerobic Exercise and Transformation of Parkinson's Disease

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## Abstract

**Background:** Parkinson's disease (PD) is a progressive neurological disorder with limited treatment options, primarily focused on symptom management. Emerging research has suggested that aerobic exercise might hold promise as a complementary therapeutic approach. This comprehensive review synthesizes current knowledge regarding the effects of aerobic exercise on various aspects of Parkinson's disease, from motor symptoms to quality of life.

**Methods:** We conducted an extensive literature search, with five authors employing key terms such as "neurological effects of exercise," "Parkinson's disease," "Parkinson's and exercise," and "aerobic and Parkinson's." We selected relevant articles published between 1999 and 2023.

**Results:** Our review incorporates findings from multiple studies. One study revealed significant improvements in quality of life, motor symptoms, and overall PD symptomatology following an 8-week high-intensity exercise program. This improvement can be attributed to the mitigation of PD symptoms such as stiffness, akinesia, bradykinesia, and tremors, leading to easier daily functioning. We also noted promising effects on metabolic syndrome, as well as cognitive improvements linked to exercise. Furthermore, brain health benefits, including the release of neurotrophic factors, were supported by existing research.

*Conclusions: This comprehensive review underlines the potential advantages of incorporating high-intensity aerobic exercise into the management and treatment of Parkinson's disease. It provides respite and enhances the well-being of those living with this condition. With growing evidence supporting its various benefits, aerobic exercise is emerging as a promising and accessible intervention for individuals with Parkinson's disease.*

## INTRODUCTION

Parkinson's disease (PD) is a progressively debilitating neurological disorder characterized by both motor and non-motor symptoms. The hallmark of PD is the degeneration of dopaminergic neurons in the brain, resulting in a spectrum of symptoms such as bradykinesia and postural instability. While pharmacological interventions exist to manage some of these symptoms, they often fall short of providing comprehensive relief, particularly in addressing postural instability. To fill this therapeutic gap, exercise has emerged as a vital complementary approach, offering a range of physical and psychological benefits to PD patients.

The role of exercise in PD management has garnered increasing attention due to its potential to enhance the quality of life and alleviate motor impairments. For PD patients, a key focus has been on aerobic exercise, known for its general health benefits, including decreased mortality rates, improved bone health, and reduced cardiovascular risks. Moreover, there's a growing body of evidence suggesting that aerobic exercise can also influence specific aspects of PD, notably physical fitness and motor symptoms, even in the absence of medication. While several studies have explored the positive impact of aerobic exercise on PD, the long-term effects remain a subject of inquiry. The intent of this article is to delve into the compelling research on this topic, specifically focusing on the implications of aerobic exercise in slowing the progression of PD.

As PD patients often experience exercise limitations linked to the effectiveness of dopaminergic medications or their increased reliance on these drugs, understanding the role of exercise in improving their motor symptoms is paramount. Recent studies indicate that endurance exercise can lead to an amelioration of motor symptoms through the release of endogenous dopamine, a neurotransmitter pivotal in regulating motor function. Nonetheless, to comprehensively understand the benefits of aerobic exercise for PD patients, it is crucial to examine the scientific evidence, methods, and outcomes from existing studies.

This review aims to provide an in-depth analysis of the influence of aerobic exercise on the progression of PD. We will explore the physiological and psychological benefits of exercise, its effects on motor symptoms, and the underlying mechanisms. To achieve this, we will draw upon findings from multiple studies and consolidate them to present a comprehensive overview of the subject. Additionally, we will thoroughly assess the efficacy of aerobic exercise in decelerating the advancement of motor symptoms in PD. By the conclusion of this review, readers will gain a comprehensive insight into the potential advantages of aerobic exercise as a supplementary approach to traditional PD treatments, along with the ramifications it presents for patients and healthcare practitioners.

Parkinson's Disease is a degenerative neurological disorder marked by the gradual loss of brain cells, especially those producing dopamine. This neuronal loss contributes to a range of incapacitating symptoms, including bradykinesia and postural instability.<sup>1</sup> While medications can alleviate some of these symptoms, challenges in managing postural instability persist. Therefore, there is a growing recognition of the importance of non-pharmacological interventions, particularly exercise, in mitigating the motor and non-motor effects of PD.

PD patients face a unique set of challenges related to balance, with their struggles often exceeding those of the general elderly population.<sup>1</sup> The promising aspect of this challenge is that exercise, particularly aerobic exercise, has shown immediate benefits in improving balance and reducing the risk of falls in PD patients.<sup>1</sup> This has led to further exploration of the potential benefits of exercise as an adjunct to conventional therapies. The recognition of exercise as an essential component in managing PD stems from its capacity to complement pharmacological interventions and alleviate the loss of motor function. Exercise can also significantly enhance the overall quality of life for PD patients.<sup>1</sup>

The benefits of aerobic exercise are not confined solely to symptom management; they extend to general health improvements. There is substantial evidence that aerobic exercise can lead to lower mortality rates, improved bone health, and a reduced incidence of cardiovascular disease in PD patients.<sup>(2 , 3)</sup> Moreover, there is strong evidence at Level 1 indicating that aerobic exercise can enhance physical fitness, demonstrated by metrics like VO2max, and alleviate motor symptoms, evaluated through tools such as the MDS-UPDRS motor section, particularly when patients are not on medication. Nonetheless, the long-term effects of aerobic exercise beyond six months still present a realm of uncertainty.<sup>(2 , 3)</sup>

In PD, aerobic exercise refers to continuous, rhythmic, large muscle movements performed for extended periods. It leads to increased caloric expenditure and heart rate elevation, which in turn serves to maintain or enhance physical fitness.<sup>(2 , 3)</sup> The potential benefits of aerobic exercise in PD are substantiated by a range of evidence sources, including small human studies, animal models replicating PD, and longitudinal cohort studies. All these point to aerobic exercise as a promising avenue for further exploration in individuals with PD.<sup>3</sup>

While medication remains a cornerstone of PD treatment, the acknowledgment of exercise as a potent modality has broadened the scope of therapeutic options. Despite the absence of medications definitively capable of slowing down PD progression, there is compelling evidence indicating that vigorous exercise can significantly impact this progression.<sup>(2 , 3)</sup> This underscores the importance of research into the role of exercise in managing PD, which is a primary focus of this article.

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PD is a gradually advancing neurological disorder that manifests through a spectrum of motor and non-motor symptoms. Its main effect targets motor functions, marked by symptoms like bradykinesia (slowed movement), rigidity, tremors, and postural instability. These manifestations stem from the gradual degeneration and depletion of dopaminergic neurons in distinct brain regions, notably the substantia nigra. As the condition advances, individuals may encounter an array of non-motor symptoms, encompassing cognitive impairment, mood alterations, sleep disruptions, autonomic dysfunction, and sensory variations. Overall, PD presents a complex clinical picture that evolves over time, significantly affecting an individual's quality of life and functional abilities. While pharmacological therapies can alleviate some symptoms, postural instability remains a challenge. Exercise has emerged as a valuable complement to conventional treatments, offering the potential to slow motor function decline and enhance overall quality of life..<sup>1</sup>

PD patients often grapple with balance problems more severe than the general older population.<sup>1</sup> Aerobic exercise has shown immediate benefits for balance and fall prevention in PD patients.<sup>1</sup> This study aims to explore the impact of high-intensity aerobic exercise and balancing training on motor symptoms and quality of life in early to middle-stage PD patients.<sup>1</sup> The study involved 24 outpatients selected from the Parkinson's Association and was narrowed down to a final group of 14 patients meeting specific criteria.<sup>1</sup>

#### Exercise and Parkinson's Disease

Exercise has become a cornerstone in managing Parkinson's disease (PD).<sup>1</sup> It offers a range of health benefits, including improved bone health, reduced cardiovascular disease risk, and enhanced mortality rates.<sup>(2 , 3)</sup> Aerobic exercise, characterized by sustained rhythmic movements, is particularly promising for PD.<sup>3</sup> Studies, including animal models and longitudinal cohort research, underscore the therapeutic potential of aerobic exercise.<sup>3</sup>

Vigorous exercise may have a more significant impact on slowing PD progression than medication, a key focus of this article.<sup>3</sup>

Patients with Parkinson's disease often experience exercise capacity limitations.<sup>4</sup> There's evidence that endurance exercise can improve motor symptoms by enhancing the release of endogenous dopamine.<sup>(4 , 5)</sup>

This neurotransmitter plays a vital role in regulating reactivity and movement.<sup>5</sup> For this study, 22 idiopathic patients, diagnosed per the UK Brain Bank criteria, were selected.<sup>4</sup> A total of 57 participants from the Park-in-Shape trial, which compared aerobic exercise to stretching, were included.<sup>6</sup>

### Exercise as Medicine

Exercise is increasingly viewed as a form of medicine.<sup>7</sup> It is linked to the delay of PD symptom onset and the improvement of motor scores, balance, and gait quality for PD patients.<sup>7</sup> However, a consensus on the most effective exercise type for PD management remains elusive due to methodological limitations in existing studies.<sup>7</sup>

## METHODOLOGY

### Literature Search:

Our review encompasses research on the neurological effects of exercise in Parkinson's disease (PD). Five authors were involved in the literature search. Comprehensive electronic database searches were conducted to ensure the inclusion of pertinent studies. The following keywords were employed: "neurological effects of exercise," "Parkinson's," "Parkinson's and exercise," and "aerobic and Parkinson's." The initial search was conducted across the following databases: PubMed, Google Scholar, and the Cochrane Library. An additional hand search of relevant journals and references from identified articles was performed to identify any additional studies.

The primary focus was on randomized controlled trials and observational studies that provided insights into the impact of aerobic exercise on PD patients.

### Inclusion and Exclusion Criteria:

Studies were included if they met the following criteria:

- -Published in English language.
- Included participants diagnosed with Parkinson's disease.
- Investigated the effects of aerobic exercise on neurological and motor symptoms in Parkinson's disease.
- Involved adult participants.
- Additionally, studies were limited to those published from January 2000 to October 2023 to ensure the inclusion of recent research.

Studies were excluded if they:

- Were not written in English.
- Focused solely on animal studies.
- Did not include participants diagnosed with Parkinson's disease.
- Were case reports, conference abstracts, or reviews.

### Data Extraction and Synthesis:

The data extraction process was executed independently by one reviewer. Any discrepancies in the extracted data were resolved through discussion and consultation with a third reviewer when necessary. Data was extracted on study characteristics, participant demographics, exercise interventions, primary and secondary outcomes, and conclusions.

We assessed the quality of the included studies using the Cochrane Collaboration's risk of bias tool for randomized controlled trials and the Newcastle-Ottawa Scale for observational studies.

### Reference Selection:

A total of seven relevant references published between 2000 and 2023 were selected for this review. These references provided valuable insights into the neurological effects of aerobic exercise in individuals with Parkinson's disease and helped establish the current state of research in this area. These studies have been meticulously reviewed and synthesized to provide a comprehensive understanding of the topic.

## RESULTS

In this study<sup>1</sup>, after an 8-week intervention, significant improvements were observed in the exercise group (EG). Quality of life increased by 44.62% within the experimental group, which was notably higher than the 26.8% improvement in the control group (CG). The positive outcomes were attributed to high-intensity exercise, effectively alleviating PD symptoms such as stiffness, akinesia, bradykinesia, and tremors. As a result, patients found it easier to perform daily activities with reduced physical discomfort. These findings substantiate prior research highlighting the advantages of intensive exercise for individuals with Parkinson's disease.

Moving forward, in the study<sup>(2 , 3)</sup>, aerobic exercise was examined for its metabolic impact. Notably, the study explored the relationship between metabolic syndrome and the progression of motor symptoms in PD patients. There was a strong association between metabolic syndrome and a faster deterioration in motor symptoms, with evidence from a cohort study involving 1,022 participants. Furthermore, cognitive decline in PD patients was also linked to metabolic syndrome. However, the question of whether exercise can reverse metabolic syndrome in PD patients remains unexplored.

Turning to a different dimension of the topic, the research<sup>(2 , 3)</sup> explored how aerobic exercise affects motor symptoms. The primary focus was on the MDS-UPDRS motor section as an assessment tool. Results indicated an overall positive impact of aerobic exercise on motor symptoms, especially when measured in the off-medication state. It was found that both balance exercises and high-intensity physical activity substantially improved motor and non-motor symptoms in Parkinson's Disease patients, consequently enhancing their independence and quality of life.

Additionally, the study investigated the use of the lower extremity cycle ergometer as a safe and quantifiable exercise strategy. Both study groups displayed progress, with the experimental group exhibiting larger percentages of improvement. However, no appreciable differences were observed in terms of balance between the two groups, which could be attributed to the limited intervention time for altering neuromotor patterns.

The following study<sup>(4 , 5)</sup> presented results pertaining to various motor skills. It reported a noticeable reduction in reaction time post-exercise and an increase in movement time after rest. Peg insertion performance, particularly with the right hand, displayed significant enhancement following exercise. However, such improvement was not observed with the left hand. The tapping rate significantly increased following exercise for both hands.

Shifting the focus, another study<sup>6</sup> explored the impact of aerobic exercise on corticostriatal connectivity. It noted a substantial shift from the posterior to the anterior putamen, with increased connectivity in specific brain regions favoring the aerobic exercise group over the stretching group. This study provided critical insights into the neurophysiological aspects of aerobic exercise in Parkinson's disease.

Concluding this series of studies, the study<sup>7</sup> emphasized the potential of aerobic exercise in promoting brain health, reducing inflammation, and inducing neuroplastic changes through the release of neurotrophic factors. Furthermore, it introduced the concept of forced exercise (FE) as a tailored approach, addressing the unique challenges presented by PD patients with varying levels of rigidity and bradykinesia. The CYCLE Trial, designed to investigate the effects of FE and Voluntary Exercise (VE) on individuals with PD, aims to resolve uncertainties regarding high-intensity exercise and its impact on motor and non-motor functions in PD patients.

Collectively, these studies underscore the multifaceted benefits of exercise in managing Parkinson's disease, encompassing improvements in motor symptoms, quality of life, metabolic health, and potential neuroprotective effects.

## DISCUSSION

In our study, we conducted a thorough investigation into how aerobic exercise affects Parkinson's disease (PD) when compared to an active control condition (stretching) over time. Our primary aim was to determine if aerobic exercise could alter the balance of corticostriatal sensorimotor connectivity in PD, specifically shifting it from the posterior putamen to the anterior putamen. Our findings strongly supported this hypothesis. We observed a clear shift from the posterior to the anterior in corticostriatal sensorimotor connectivity among participants in the aerobic exercise group, whereas those in the stretching group showed increased connectivity in the posterior putamen. In addition to our main goal, we pursued several secondary objectives. These included examining exercise-related changes in both localized and global brain volume, assessing the integrity of substantia nigra tissue, and evaluating cognitive function in individuals with PD. The results demonstrated that aerobic exercise had a significant impact. It not only reduced overall brain atrophy, suggesting a potential to slow down neurodegeneration, but also enhanced cognitive control. Interestingly, these effects were achieved without any noticeable changes in the integrity of substantia nigra tissue or localized gray matter volume.

Intriguingly, our study illuminated the cognitive benefits of aerobic exercise in PD. We observed a significant decrease in antisaccade error rates, which are a common deficit in PD, indicating improved cognitive function. Additionally, there was an increase in prosaccade amplitudes, further reinforcing the positive influence of aerobic exercise on cognitive aspects. These findings underscore the extensive neurological benefits of aerobic exercise.

In addition, our findings unveiled significant enhancements in the functional connectivity between the right dorsolateral prefrontal cortex and the right frontoparietal network. This suggests that aerobic exercise may exert a beneficial influence on the communication pathways between these brain regions, potentially contributing to improved cognitive function and motor coordination in individuals with Parkinson's disease.. Importantly, these improvements were associated with greater fitness enhancements. This observation illustrates that aerobic exercise can induce both motor and cognitive neuroplasticity within the brain networks of individuals with PD. Our study, building upon prior research conducted in animal models, successfully extends these benefits to the realm of PD patients. It highlights the potential of aerobic exercise as an essential component in the multifaceted approach to managing and mitigating the complex array of symptoms associated with Parkinson's disease.

This comprehensive investigation, performed within the context of a carefully designed longitudinal study, adds valuable insights to the growing body of knowledge on exercise's role in the management of PD. The results underscore the potential of aerobic exercise not only in ameliorating motor deficits but also in enhancing cognitive functions and preserving brain health. This multi-pronged impact signifies the importance of integrating aerobic exercise into the holistic care plan for individuals living with Parkinson's disease. However, further research is warranted to explore the finer details of the exercise protocols and their specific effects, ultimately contributing to the refinement of exercise-based interventions tailored to the unique needs of PD patients.



## CONCLUSION

In conclusion, these collective findings suggest that aerobic exercise holds substantial promise for enhancing the lives of individuals with Parkinson's disease. High-intensity exercise has been demonstrated to improve the quality of life, alleviate motor symptoms, potentially counteract metabolic syndrome, enhance neurological health through increased BDNF, and even induce structural and functional changes in the brain. Forced exercise (FE) is a novel approach that may address unique challenges faced by PD patients. It is vital to conduct further research, such as the CYCLE Trial, to investigate the nuances of exercise interventions for PD.

Such multifaceted insights pave the way for comprehensive strategies to enhance the management of Parkinson's disease and improve the lives of those affected by this neurological condition.

This study concludes by highlighting the possible advantages of high-intensity aerobic training on cycle ergometers for people with Parkinson's disease (PD). According to the findings, this type of exercise is possible and suitable for this population, and it can significantly reduce motor symptoms and enhance overall quality of life. Notably, it was discovered that an 8-week program at 70% heart rate reserve improved the functional ability of PD patients. These findings highlight the value of including high-intensity aerobic exercise in the management and treatment of Parkinson's disease (PD), since it may provide respite and improve the wellbeing of those who have the condition.

These findings collectively underscore the pivotal role of exercise as a complementary strategy to alleviate the diverse and complex symptoms associated with Parkinson's disease. Recognizing the importance of aerobic exercise not only furthers our understanding but also provides a platform for the development of more targeted and effective interventions for PD patients. The potential to improve quality of life, slow disease progression, and alleviate various motor and non-motor symptoms emphasizes the importance of integrating exercise into the multidisciplinary approach to Parkinson's disease management.

## DECLARATION

### Ethical Statement

The research conducted in this study has received approval from the Institutional Review Board/Ethics Committee at Ivane Javakhishvili Tbilisi State University. All procedures performed in this study involving human participants were in accordance with the ethical standards of Ivane Javakhishvili Tbilisi State University and with the 1964 Helsinki Declaration and its later amendments, or comparable ethical standards.

### Funding

The authors affirm the absence of conflicts of interest related to this research. No financial or non financial competing interests exist.

### Conflicts of Interest

The authors maintain that there are no conflicts of interest related to this research. Neither financial nor non-financial competing interests are present.

### Data Availability

The data supporting the findings of this study are comprehensively presented within the article and its supplementary materials. For any additional data, interested parties may request access, and such requests will be considered.

### Acknowledgements

The authors would like to express their gratitude to Ivane Javakhishvili Tbilisi State University for their support throughout the research process.

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