



Review Article

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# The Effect of Exercise on Balance: Emphasis on Women Diagnosed with Parkinson's Disease



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## Abstract

The motor symptoms associated with Parkinson's disease include tremors, dyskinesia, rigidity, and posture and gait abnormalities. The incidence, prevalence and mortality rates of the disease are lower in women compared to men, possibly due to the neuroprotective role of estrogen. Aerobic, resistance and flexibility exercise protocols may be effective at improving the functional limitations, including balance, that are a result of the inherent pathophysiology of Parkinson's disease. Resistance exercise that targets lower torso, pelvic and leg muscles elicits strength changes that allows for better control of posture and balance, thereby potentially lessening chronic fatigue and preventing falls.

**Keywords:** Parkinson's disease; Women; Female; Exercise; Balance; Aerobic; Resistance; Balance; Fatigue; Bone mineral density

**Abbreviations:** PD: Parkinson's Disease; BMD: Bone Mineral Density

## Introduction

Parkinson's disease (PD) is a neurodegenerative condition caused by a reduction in dopaminergic neurons located in the substantia nigra of the brain [1]. The disease is characterized by muscle tremors, rigidity, and dyskinesia leading to posture and gait abnormalities [1]. Although the incidence ratio of males to females is approximately 1.46 [2], the prevalence of PD among men is doubled when compared to women [3]. Females typically have a lower mortality rate associated with PD due to: 1) the overall longer life expectancy when compared to men in the general population, and; 2) the factors that predict high mortality in those with PD, including cognitive impairment and posture and gait abnormalities, are less common in women [4-6].

In males, there is therefore a greater predisposition to develop PD [7]. This bias may be due to the molecular pathology of PD. Gene expression profiles in normal substantia nigra dopaminergic neurons are sex-specific and the survivability of these neurons are dependent on molecular pathways that are very different in men and women [7]. Therefore, women are thought to have greater protection from PD when compared to men, which may be due to estrogen concentrations [7].

Estrogen plays a significant role in the pathophysiology and progression of PD in women. Estrogen influences dopamine synthesis and release while inhibiting dopamine uptake [8]. The higher concentrations of estrogen is a possible reason for the more benign phenotype in women when compared to men [9,10], particularly before a course of medication has begun [11]. Estrogen may have a protective effect, preventing toxins from negatively affecting and possibly degrading neurons in the substantia nigra [8]. However, the protective effect of estrogen was not evident in other studies, which included women participants who reported a more rapid onset of symptoms, including dyskinesia, upon diagnosis [12-14].

With regard to motor symptoms, women typically present more with tremors [9] and dyskinesia, but not rigidity [15], when compared to men. Upon the analysis of non-motor symptoms, constipation, restless legs, pain and emotional characteristics such as nervousness and sadness were more prevalent in women [15-17]. A reduction in visuospatial cognition also occurs more frequently in women [11]. When compared to women without PD, women with PD typically report a more frequent loss of interest and anxiety [18].

## Effect of Aerobic Exercise on Balance

Genders are not analyzed separately in the majority of studies that include exercise as an intervention to investigate functional changes, including balance, in adults with PD. Several studies have included a large number of female participants with PD. Cakit et al. [19] reported significant improvements in the scores on the Berg Balance Scale following 8 weeks of treadmill training in which intensity was incrementally increased using speed in 31 individuals (15 females) with PD [19]. In another study, no difference in functional reach scores [20,21] were reported between a traditional aerobic exercise program, a flexibility program, and a home-based exercise program after 16 months in 121 adults (45 females) with early- to mid-stage PD [22]. Other non-conventional forms of aerobic exercise have demonstrated improvements in balance, such as robotic gait training [23], dance therapy [24-26], boxing training [27] and whole-body vibration [28] in both women and men with PD.

## Effect of Spinal Flexibility and Resistance Exercise on Balance

Poor spinal flexibility is moderately correlated with functional limitations in those with PD [29]. Using regression analysis, Shenkman et al. [29] found a greater correlation between females with PD and both poor spinal flexibility and balance [29]. Balance in humans is often correlated with postural control [30]. In fact, many of the same tools are used to assess both posture and balance. When assessing lower limb strength, Pääsuke et al. [31] found differing reaction times and maximum isometric force between the legs in females with PD [31]. This may be due to the postural asymmetry, and thus balance impairment, that is prevalent with PD. In a group of 20 adults (7 women) with PD, power in the leg muscles (i.e., leg extensors, knee flexors, hip extensors, hip abductors) was significantly increased after 12 weeks of resistance exercise, leading to improvements with stepping reaction time, maximal balance range and time in single leg stance [32].

## Exercise, Balance, and Fatigue

To achieve proper balance, the muscles that control and regulate balance must be strengthened through force generation within the skeletal muscles. The generation of necessary force from motor tasks, coupled with the power loss in muscle due to bradykinesia and tremors, may lead to fatigue in those with PD [33-35]. However, there is an inverse relationship between the frequency of regular aerobic exercise and chronic fatigue both women and men with PD [36].

## Exercise, Balance, and Bone Mineral Density

Postural instability and poor balance, in addition to other neuromuscular and visual impairments, are significant and independent risk factors for hip fracture in elderly mobile women [37]. Falls are the most common causes of emergency

hospital admissions in those with PD due to the inherent pathophysiology of PD and a lower than normal femoral-neck bone mineral density (BMD), which may lead to osteoporosis [38]. The onset and progression of osteoporosis in individuals diagnosed with PD may be due to a limited exposure to sunlight, a deficiency in vitamin D, having a classification of advanced PD, immobilization, hormonal imbalances, or poor dietary habits [39]. In postmenopausal women, exercise, with additional treatments (e.g., pharmacological supplementation), can maintain and even increase BMD in this population [40,41]. Exercise programs that incorporate muscle strengthening and balance can also potentially reduce the number of falls, thereby preventing hip fractures [42]. In women with PD, hip BMD is independently associated with leg muscle strength, as this muscle strength accounts for 8.8 to 10.6% of the variation observed in hip BMD [43].

## Conclusion

Women with PD have greater levels of disability and reduced quality-of-life when compared to men with PD. Both aerobic and resistance exercise may elicit functional changes, including balance, in women diagnosed with PD. Exercise may also reduce chronic fatigue and increase or maintain BMD, thereby improving balance and decreasing the risk of hip fractures. More studies are needed that include an analysis of functional changes, using groups separated by gender, following some exercise intervention.

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