

EXERCISE FREQUENCY AND PHYSICAL FUNCTION IN PARKINSON'S DISEASE

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Abstract: *The purpose of the present study was to identify the changes in physical function of individuals with Parkinson's disease (PD) without dementia following a high-frequency and a low-frequency exercise intervention program. Participants were divided into two training frequency groups: high-frequency: 4-5 times each week ($N = 23$, $M_{age} = 68.6$ ($SD = 5.8$), 16 males), and low-frequency: 3 times or less each week ($N = 20$, $M_{age} = 67.6$ ($SD = 4.5$), 10 males). All participants completed the Short Physical Performance Battery (SPPB) at baseline, and at the conclusion of 12 weeks of exercise intervention. Summary performance scores for the SPPB used the summation of the test scores for standing balance, walking speed, and rising from a chair 5 times. . Based on a mixed factorial ANOVA, significant interaction was indicated between time and group, $F(1, 41) = 8.37$, $p < .05$, $\eta_p^2 = 0.17$ for SPPB summary performance scores, and a significant interaction between group and task $F(2, 82) = 3.65$, $p < 0.05$, $\eta_p^2 = 0.08$, for the SPPB scores calculated for each of the three tasks separately. Based on the data analysis it is apparent that changes in physical function in individuals with Parkinson's disease are dependent on the frequency of weekly exercise, with higher frequency having a better impact than lower frequency.*

Key words: *Physical function, strength, balance, Parkinson's disease.*

1. Introduction

Parkinson's disease (PD) is a movement disorder caused by an imbalance of chemical messengers in the brain. The primary messenger affected is the neurotransmitter called dopamine, concentrated in the substantia nigra of the midbrain [35]. When neurons in the substantia nigra degenerate, the resulting loss of dopamine (DA) causes the nerve cells of the striatum to fire excessively.

This makes it difficult to control movements, and is demonstrated by primary motor symptoms associated with PD, including: bradykinesia, postural instability, muscle rigidity, and resting tremor [37, 38]. Symptomatically, the typical features characterize the onset and progression of PD while functional deficits are the loss of muscle strength, postural stability and balance that effect the basis of motor control and the ability to plan, initiate and execute purposeful movement [33].

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This is especially evident in the inability to initiate and control gait. Parkinsonian gait is characterized by shuffling steps, a general slowness of movement or total loss of movement (akinesia) in extreme cases [1]. Functional components in PD demonstrate spatial difficulties such as reduced stride lengths, and temporal components difficulties such as reduced walking speed and increased duration of double support and cadence rate [15, 20, 27]. Patients have difficulty initiating a movement, but also demonstrate a reduced ability to stop or change directions [27]. The loss of capabilities due to gait and balance problems are specific to functional decline in quality of life, morbidity, and mortality in patients with PD [10, 23, 32, 34]. The loss of function represent a major threat to ambulatory independence, causing pain, cessation of physical activities, and the onset of cognitive decline.

Although PD is a degenerative disease, inactivity may accelerate the progression of symptoms [39]. Studies have shown that moderate and high levels of physical activity lowers the risk of developing PD [2], and also suggested that participating with regularity in exercise programs can postpone the onset of the disease [40]. A recent cross – sectional study conducted by Ellis and colleagues [7] identified three major perceived barriers to exercise, including low expectations from exercise, lack of time to exercise, and fear of falling. Recent reviews and research suggest also that exercise is important in the early stages of PD, and that can have positive effects on both motor and non-motor signs and symptoms of the disease [18], [22], [31], [41]

Different types of exercises were proposed by intervention and randomized controlled trials in order to minimize the negative effects of PD on the motor and functional performance. These studies identified specific exercises to improve mobility [17], [25], [41], muscular strength [5, 6], balance [16], aerobic conditioning

[36], posture [26] and gait [25]. Although the benefits of exercise for PD are widely recognized, there is still a lack of evidence regarding the optimal delivery content, and more precisely the frequency of exercise that triggers the most beneficial effects.

2. Objectives

The objective of the present study was to examine the effects of two different frequencies of weekly exercise on physical function in individuals with PD. We hypothesized that exercising 4-5 times/week rather than 3 times or less each week will have a greater impact on walking speed, balance and lower extremity strength, as measured by the Short Physical Performance Battery.

3. Materials and Methods

3.1. Participants

Initially, 90 individuals with PD attended a screening visit; based on inclusion and exclusion criteria 46 individuals were recruited (n = 46; 26 males and 20 females) from the Atlanta Metropolitan area through the PD Support Group meetings. After the recruitment, 3 females dropped out from the study. Individuals were included based on the following criteria: 1) diagnosis of PD; 2) a Montreal Cognitive Assessment (MoCA) scores ≥ 22 (a score lower than 21 indicates increased odds of dementia) [24]; 3) age between 50 yr. and 80 yr. and 4) medical clearance for exercise and absence of other health related problems that could interfere with safe participation in an exercise training program. Participants were excluded from the study if they were experiencing any neurological severe motoric impairment that impacted their mobility, had a cardiovascular disease or metabolic disorder, or had undergone deep brain stimulation surgery. A summary of the clinical and demographic features of the participants is presented in Table 1.

Table 1
Demographic and clinical features of 43 patients with Parkinson's disease (PD)

Variable	HF exercise	LF exercise	p
Number of patients	23	20	
Male/ Female	16/7 mean (SD)	10/10 mean (SD)	
Age (years)	68.6 (5.8)	67.65 (4.5)	0.55
Age of PD onset (years)	57.5 (12.9)	58 (13.5)	0.62
PD duration (years)	10.6 (5.2)	9.8 (4.9)	0.83
Hoehn and Yahr	2.3 (0.5)	2.5 (0.4)	0.27
Education (years)	18.3 (2.9)	17.9 (2.7)	0.81
Exercise habits (times/ week)	5.1 (1.1)	2.2 (0.6)	< 0.001*
MoCA score	25.5 (2.7)	25.4 (2.5)	0.88
UPDRS motor score	26.4 (4.3)	26.5 (5.0)	0.95

Legend: HF, high – frequency; LF, low – frequency; SD, standard deviation; MoCA, Montreal Cognitive Assessment; *significant difference ($p < 0.05$); UPDRS, Unified Parkinson's Disease Rating Scale.

1.1. Procedures

Participants were informed on the components of the study and signed the University of Georgia Institutional Review Board consent forms prior to beginning testing and exercising. The “off-times”, which are an invariable consequence of levodopa and dopamine agonists treatment in patients with PD, were controlled and diminished by assessing and exercising the participants after medicine ingestion, when clinically - defined best on state [28]. "Off-time" refers to periods of the day when the medication is not working appropriately, causing worsening of motor and non-motor PD symptoms. Levodopa administration has been shown to improve motor function and subjective alertness without compromising either reaction time or accuracy [19]. Prolonged levodopa usage leads to a decline in efficacy which creates fluctuations in the motor performance of voluntary movements, but only secondary, non-significant fluctuations in cognitive, autonomic and sensory functions [3]. Medication prescribed for control of PD was not adjusted or withdrawn for any participants during the study. Participants completed two testing sessions conducted one week apart prior to beginning the exercise intervention, and in the first 48

hours after the conclusion of 12 weeks of exercise training. During the first session, participants completed a demographic and medical history questionnaire, and took a screening test (MoCA), administered by a PD specialist.

During session 2, all participants performed the Short Physical Performance Battery (SPPB), a group of measures that combines the results of the preferred walking speed, chair stand, and balance tests [13].

At the end of the 12 weeks of multimodal exercise intervention, all participants completed a systematic replication of session 2. A detailed description of the pre- exercise and post-exercise protocols for the SPPB is presented in the section below.

Short Physical Performance Battery

The Short Physical Performance Battery (SPPB) is one of the most common tools to measure physical performance in population studies on aging [11]. The SPPB captures a hierarchy of functioning from high levels of function to severe deterioration of lower-extremity function, with higher scores indicating better lower-body function. The SPPB is composed of

three tasks: a hierarchical balance task, a short walk at the usual speed, and five repetitive chair stands. Low scores in the SPPB have predictive value for a wide range of health outcomes: mobility loss, disability, and hospitalization, length of hospital stay, nursing home admission, and death [12], [29], [42].

For tests of standing balance, participants attempted to maintain the side – by – side, semi - tandem, and tandem positions for 10 seconds. Participants were scored 1 if they could hold a side – by – side stand for 10 seconds but were unable to hold a semi - tandem stand for 10 seconds, 2 if they held a semi - tandem stand for 10 seconds but were unable to hold a full tandem stand for more than 2 seconds, 3 if they held the full tandem stand for 3 to 9 seconds, and 4 if they held the full tandem stand for 10 seconds.

A usual pace, 8 – ft. walk was timed from a standing start, and participants were scored according to quartiles of performance. Time on the faster of two walks was used to define scores: score of 1: ≥ 5.7 seconds (≤ 0.43 m/s); score of 2: 4.1 – 5.6 seconds (0.44 – 0.60 m/s); score of 3: 3.2 to 4.0 seconds (0.61 – 0.77 m/s); score of 4: ≤ 3.1 seconds (≥ 0.78 m/s).

Participants were asked to fold their arms across their chest and to stand up once from a chair. If successful they were asked to stand up and sit down five times as quick as possible. Quartiles of performance for the repeat chair stands were used to define scores as follows: score of 1: > 16.7 seconds; score of 2: 16.6 – 13.7 seconds; score of 3: 13.6 – 11.2 seconds; score of 4: ≤ 11.1 seconds. A summary performance score was created by summation of the scores for tests of standing balance, gait speed, and rising from a chair 5 times.

Previous studies have shown high levels of correlation between the presence of some chronic conditions and lower levels of SPPB [8] and high predictive values of SPPB for disability, risk for mortality and

nursing home admission [11, 12], [14]. Also, in older acute care inpatients, SPPB is a valid indicator of functional and clinical status; SPPB score at hospital admission is an independent predictor of the length of hospital stay [42].

1.2. Exercise Protocol

All participants engaged in group exercise classes organized under the auspice of American Parkinson's Disease Association (APDA). The activities were consistent at all five centers; they included aerobic activities such as walking, running, stationary bike, water aerobics; resistance exercises with bands and dumbbells, and movement activities such as Zumba and Tai Chi. Training was conducted by instructors who were certified by APDA. The exercise intervention was goal oriented and focused on aspects of functional ability specific to people with PD. The weekly exercise frequency, the types of exercises, the duration and perceived intensity, as well as adverse events were documented through individual daily exercise logs reported by each participant in the study. The intensity and type of the exercise intervention was matched for all the participants in the study, and the frequency was varied by group: high-frequency group exercised 4-5 times/ week, and low frequency ≤ 3 times/ week. A paired sample t-test revealed that the high-frequency group ($M=2.3$, $SD=0.92$) and the low-frequency exercise group ($M=2.15$, $SD=0.74$) were not significantly different in exercise participation prior to the intervention, $t(19) = -0.64$, $p=0.527$. The perceived intensity of exercise, reported by participants in the study, was on average moderate-high, with no significant differences between the two groups.

1.3. Statistical Analyses

Summary performance scores for SPPB were calculated as recommended by Guralnik et al. [13]. Participants received a score from 0 (worst performance) to 4 (best performance) on each of the three individual tasks; the scores were then summed up to calculate the ordinal scores ranging from 0 (worst performance) to 12 (best performance). For the composite scores, an initial 2 (times) \times 2 (groups) mixed factorial ANOVA with time as the within subjects factor was conducted to assess the changes in the overall physical function following exercise. Further, a 2 (times) \times 3 (conditions) \times 2 (groups) mixed factorial ANOVA, with time and condition as the within subjects factors, was performed to identify changes on each of the three tasks following the exercise intervention. In addition, linear regression was used to identify the relationship between the difference in executive function and walking speed pre – exercise and post – exercise. Analyses were conducted using SPSS 22 software [4]. The $p = 0.05$ rejection level was used in all analyses.

2. Results and Discussion

Means of SPPB composite scores pre- and post- exercise are presented in Table 2. Results revealed a significant interaction between time and group, $F(1, 41) = 8.37$, $p < .05$, $\eta_p^2 = 0.17$, suggesting a greater improvement in physical function for the high-frequency exercise group after the intervention. Post-hoc t -tests revealed that the two groups were not significantly different before the intervention, $t = 0.65$, $p = 0.51$, but differed significantly after the exercise training, $t = 4.40$, $p < 0.01$. Next, a mixed factorial ANOVA was performed with time and task as the within subjects factors. Means of SPPB scores for each independent task are presented in Table 3. Results revealed a significant interaction between task and group, $F(2, 82) = 3.65$, $p < 0.05$, $\eta_p^2 = 0.08$, suggesting that the high – frequency group performed better on each of the three physical tasks. Post-hoc t -tests indicated no significant difference at baseline for walking, balance and chair stands, and significant differences after the exercise intervention, balance: $t = 3.42$, $p < 0.01$; chair stands: $t = 2.11$, $p < 0.05$; walking speed: $t = 2.55$, $p < 0.05$.

Table 2

Short Physical Performance Battery Composite Scores by group and time

Variable	HF Exercise		LF Exercise	
	pre-exercise mean (SD)	post-exercise mean (SD)	pre-exercise mean (SD)	post-exercise mean (SD)
SPPB composite scores	7.13 (2.56)	9.47 (1.23)	6.7 (1.55)	7.75 (1.33)

Legend: HF, high – frequency; LF, low – frequency; SD, standard deviation; SPPB, Short Physical Performance Battery. Values in bold indicate a significant group difference ($p < .05$).

Short Physical Performance Battery Scores by task, group and time Table 3

Variable	HF Exercise		LF Exercise	
	pre-exercise mean (SD)	post-exercise mean (SD)	pre-exercise mean (SD)	post-exercise mean (SD)
Chair stands	15.08 (3.95)	12.11 (2.14)	14.30 (2.98)	13.84 (2.25)
Balance	2.43 (1.44)	3.34 (0.88)	1.40 (0.99)	2.25 (1.20)
Walking speed	4.23 (0.76)	3.52 (0.42)	3.97 (0.62)	4.05 (0.45)

Legend: HF, high – frequency; LF, low – frequency; SD, standard deviation; Results for chair stands and walking speed are in seconds, results for balance are represented by point-scores. Values in bold indicate a significant group difference ($p < .05$).

The purpose of the present study was to identify the effects of two different frequencies of exercise on the physical function in individuals with PD following twelve weeks of exercise training. Our findings indicate that individuals with PD that engage in multimodal exercise training at least four times a week, improve their physical function more than individuals with PD that exercise three times or less each week.

For the physical function assessment, the Short Physical Performance Battery composed of three tasks: a hierarchical balance task, a short walk at the usual speed, and five repetitive chair stands was used. Based on the initial analyses it was indicated that individuals with PD who engage in exercise training at least four times a week significantly improve their physical function compared to those individuals who participate three times or less. The significant interaction between task and group suggests that higher frequencies of exercise benefits each aspect of the physical function measured through the SPPB test when compared to lower frequencies of exercise. These findings indicate that changes in motor function in people with PD are dependent on exercise frequency intervention, and support previous studies by Fisher et al. [9] who also suggested a greater frequency and intensity in exercises interventions. Further, Fisher and colleagues [9, 30] indicated that exercise will positively influence and regulate the activity of brain circuitry responsible for the control of movement in individuals with PD, and supports our premise that cognition may be improved with exercise. Possibly, exercise can improve the dopamine signaling in individuals with PD, and increase blood flow in the brain [21]. Increased blood flow will eventually augment the delivery of oxygen, help remove the waste materials, and accelerate the metabolic demands in the brain regions exposed to plasticity due to engaging in innovative experiences like exercise. These underlying physiological mechanisms support the benefits of exercise for improving

overall functioning, and thus exercise should be an important component of treatment in PD.

3. Conclusions

In conclusion our study provides a noteworthy finding: the physical function benefits following a multimodal exercise intervention appears to be dependent on the frequency of weekly exercise, with high frequency triggering more extensive improvements. However, there is still a need to provide additional support for the optimal delivery and content of exercise interventions, and more precisely to determine the exercise types and dosage with the most promising effects on the physical function in people with PD. Our sample included individuals who had transportation problems and were reliant on caregivers' availability, so even the minimum amount of activity was helpful and could be supplemented with home programs to facilitate the frequency of the exercise program.

Addressing the aspects highlighted above may point to new pathways for the treatment of physical decline in individuals with PD. Finally, a qualitative assessment of all participants revealed that everyone felt better and more functional because of the exercise program. The psychological improvement may be an important part in dealing with a debilitating condition and loss of self – sufficient.

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