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Original Article

The Effects of Multimodal Exercise Program on Functional Capacity and Quality of Life in Elderly Patients with Parkinson's Disease

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Introduction: Parkinson's disease (PD) is a degenerative neurological illness characterized by various motor and non-motor symptoms that can lead to varying degrees of functional impairment. This study aims to investigate the effects of a multimodal exercise program (MEP) on functional capacity and quality of life in elderly patients with PD.

Methods: Thirty elderly patients with PD were randomly divided into two equal groups of MEP and control, with no significant differences in age, weight, and height. The variables of Functional Factors and Quality of Life were assessed in pre- and post-tests. MEP was performed five days a week for twelve weeks. Data were analyzed using repeated measures ANOVA at a significance level of $p < 0.05$.

Results: The study observed significant differences in quality of life, static balance, dynamic balance, wrist strength, and walking performance between the two groups of PD patients ($p < 0.001$). The mean scores of quality of life, static balance, dynamic balance, and wrist strength in the MEP group were significantly higher compared to the control group ($p < 0.001$). Additionally, after the intervention, the walking speed in the MEP group showed a significant improvement, with a lower completion time compared to the control group ($p < 0.001$).

Conclusion: MEP can be used as a useful and effective method to improve quality of life, static balance, dynamic balance**,** wrist strength and walking performance of PD patients. Therefore, MEP (resistance, aerobic, and balance) is recommended as the most effective complementary therapeutic strategy for PD.

Keywords: Multimodal Exercise Program, Parkinson’s Disease, Functional Factors, Quality of Life, Aging

Introduction

Parkinson's disease (PD) is one of the common and progressive disorders of the central nervous system, characterized by symptoms such as slowed movement, muscle stiffness, tremors, balance impairment, and a gradual decline in motor function. The prevalence of PD has increased significantly in recent years, especially among the elderly (1). This condition primarily affects individuals over the age of 50 and is one of the common causes of disability in the elderly. The exact cause of this disease is not yet fully

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understood, but genetic factors and various environmental factors such as agricultural work, the use of well water, rural living, and exposure to pesticides are considered potential contributors to its etiology (1, 2). The neuropathological hallmark of this disease is the degeneration of dopamine-producing cells in the substantia nigra of the midbrain. However, clinical symptoms become evident only after approximately 80% of these dopamine-producing cells are lost, leading to disrupted neurotransmission in the basal ganglia of the brain (3). The decrease in dopamine levels and the resulting imbalance between dopamine and acetylcholine lead to various motor dysfunctions. The most significant motor impairments in PD include reduced balance, impaired postural control, and a progressive decline in movement speed, range, strength, and quality of life. These impairments are often followed by additional complications (4). For example, an increased risk of falls in elderly patients with PD frequently leads to fractures, joint dislocations, and severe soft tissue injuries (5).

Physiologically, balance is defined as the interaction among various mechanisms for controlling balance, while biomechanically, it is described as the ability to maintain and restore the body's center of gravity within the stability limits determined by the base of support (6). Postural instability in PD arises from a combination of reduced muscle strength and other complications associated with the degeneration of dopamine-producing cells in the basal ganglia. Researchers have identified disruptions in the excitation and inhibition processes within the basal ganglia, as well as their connections through direct and indirect pathways, as the primary cause of balance problems in these patients (7). On the other hand, the symmetry of the disease combined with aging leads to an increase in the complications of PD (8).

As individuals age, changes occur in the functioning of the musculoskeletal system, vestibular system, somatosensory system, and visual system – all of which are crucial for maintaining balance. These age-related changes increase the risk of falls and subsequent injuries in older adults, such as fractures and long-term disabilities (9).

Numerous studies indicate the positive impact of physical activity on the complications and issues related to PD. Researchers have consistently emphasized non-pharmacological treatments and a multidisciplinary approach for managing PD (10, 11). Studies have shown that exercise, as a therapeutic method, is effective in increasing muscle strength and improving balance. Multimodal exercise program (MEP) includes the use of core exercise components such as strength, aerobic, and coordination training to improve the development of functional tasks for daily life (12-14). Combining different types of exercise can enhance performance, including improvements in walking, functional mobility, balance, postural control, reduction in muscle rigidity, improvement in neurotrophic markers, and slowing the progression of the disease (15). Daneshvar et al., show that both rebound and weight-supported exercises are effective on improving the range of motion, proprioception, and the quality of life of people with PD, it is recommended that the benefits of these exercises to be used in physical rehabilitation programs (16). Limited research has been conducted on the impact of MEP on the functional factors and quality of life of PD patients. Therefore, the present study aims to investigate the effects of MEP on the functional factors and quality of life in PD patients.

Methods

Study design and participants

The present study was of a quasi-experimental type. The statistical population of this study consisted of all female PD patients in the city of Isfahan in 2023, Iran. Among these individuals, 30 women from those who visited the Neurology Clinics and the Parkinson's Association in Isfahan, with at least 3 years of disease duration, were purposefully selected with the physician's consent. Thirty patients were randomly divided into two groups: MEP (n = 15) and control (n = 15). Subjects were selected based on the diagnosis of a neurologist. Inclusion criteria were: known case of PD in stages 2 or 3 according to the Hoehn and Yahr scale (17), onset stage of the disease (responding to medications), moderate stage of the disease according to the Unified Parkinson's Disease Rating Scale and voluntary agreement to participate in the study. Exclusion criteria included: history of severe spinal or lower limb injury or surgery within the past year, skeletal abnormalities that prevented the performance of the exercises and absence from more than 30% of the study sessions. All pre- and post-test clinical evaluations were conducted by a single neurologist who was blinded to the participants' group assignments.

Instruments

The Parkinson's Disease Questionnaire (PDQ-39) was used to assess the quality of life of patients with PD (18). This questionnaire comprises 39 items and is completed by the patients. It typically takes approximately 10 minutes to fill out. The 39 questions are divided into eight dimensions in the Persian version of the PDQ-39: mobility (10 questions), activities of daily living (ADL, 6 questions), emotional well-being (6 questions), stigma (4 questions), social support (3 questions), cognition (4 questions), communication (3 questions), bodily discomfort (3 questions). Each question in this questionnaire uses a five-point Likert scale, where only one option is selected. The score for each question ranges from zero (0) to four (4): "Never" = 0, "Occasionally" = 1, "Sometimes" = 2, "Often" = 3, "Always" = 4. The final score for each dimension is calculated as follows:

1. Sum the scores of all questions within that dimension.
2. Divide this sum by the number of questions in that dimension.
3. Multiply the result by 4 (the maximum score for each question).
4. Divide this value by the total number of questions in that dimension.

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5. Multiply this result by 100.

Each dimension score ranges from 0 to 100 on a linear scale, where 0 represents the best quality of life and 100 represents the worst. Furthermore, the mean score of all dimensions is calculated to obtain a single index called the Parkinson's Disease Summary Index (PDSI). The PDSI also ranges from 0 to 100, with 0 indicating the best and 100 the worst quality of life (19).

In order to assess static balance, the Sharpened-Romberg test with eyes closed was used (20). In this test, after a brief warm-up, the subjects stand barefoot with one leg (the dominant leg) in front of the other and their hands are crossed over their chest. The time each subject is able to maintain their balance with their eyes closed is considered their score

The Stand and Walk test was used to measure dynamic balance. This test requires each subject to stand up from an armless chair 45 cm above the ground without using their hands, walk a distance of three meters, and then return to the chair (21). To measure the subjects' walking speed, a distance of 10 meters was determined on the ground, and the time it took the subject to walk these 10 meters was measured by a timer (22).

A digital hand-held dynamometer was also used to measure wrist muscle strength (23).

Intervention

The MEP consisted of 3 sessions per week, each lasting 60 minutes, for a duration of 12 weeks**.** The components of this program included aerobic resistance, muscular strength, balance, motor coordination, agility, and flexibility. The MEP were performed in the sports club (24). (Table1)

Statistical analysis

SPSS software (version 22, IBM Corp., Armonk, NY, USA) was used to analyze the collected data. Shapiro-Wilk statistical test was used in order to investigate the normal distribution of data in two groups, and t-test and the repeated measures ANOVA were used to compare the variables in and between the groups at a significant level of less than 0.05.

Ethical considerations

The study protocol was approved by the Research Ethics Committee of the Islamic Azad University-Isfahan Branch (IR.IAU.KHUISF.REC.1403.264). All subjects signed written informed consent.

Results

There were no significant differences between the groups in terms of age, height, and weight. (Table 2)

Table 3 presents the mean and standard deviation for quality of life, static balance, dynamic balance, wrist strength, and walk test results in the pre- and post-tests.

Based on the analysis of repeated measures ANOVA, significant improvements were observed in all variables within both groups ($p < 0.05$). However, intergroup comparisons showed that the MEP group experienced significantly greater improvements in all measured variables compared to the control group ($p < 0.001$). These findings indicate that MEP is more effective in enhancing quality of life, balance, wrist strength, and walking performance in PD patients compared to the absence of exercise. (Table 3)

Quality of life

In the MEP group, the mean score increased from 105.68 ± 10.82 in the pre-test to 147.63 ± 13.82 in the post-test ($t = 183.166$, $p < 0.001$). In the control group, the mean score improved slightly from 104.41 ± 10.42 to 118.98 ± 12.52 ($t = 153.141$, $p < 0.001$). The intergroup comparison showed a significant effect of MEP ($F = 3161.964$, $p < 0.001$, Eta = 0.99).

Static balance

In the MEP group, the mean score improved from 5.62 ± 1.81 to 10.17 ± 4.12 ($t=89.098$, $p < 0.001$). However, in the control group, the mean score decreased slightly from 6.52 ± 2.41 to 5.98 ± 1.52 ($t = 33.816$, $p < 0.001$). Intergroup comparison indicated a significant effect of MEP ($F= 44.154$, $p < 0.001$, Eta = 0.62).

Table 1. Implementation elements of the MEP

Warm-up 5 to 10 minutes	During this time, they participated in playful activities to develop joint mobility, activate the neural-muscular muscles that would be used in the training program, and enhance functional movements (transitions).
Resistance training	Targeted exercises for different body parts, including facial muscles, shoulders, chest, arms, back, hips, calves, and thighs. For each exercise, perform 2 sets with 10 repetitions per set
Balance exercises	Exercises involving specific movements, such as seated balance exercises, standing balance exercises (with eyes open and closed), and dynamic balance exercises. Each exercise is performed for 10 to 15 seconds, with 2 sets for each movement.
Walking exercises	Steady Walking Exercises: 1 to 2 sets, with 30 to 50 steps per set. Walking and Turning Exercises: 1 to 2 rounds per set, for a total of 2 sets. Obstacle Crossing Exercises: 5 to 10 steps in each direction, for a total of 2 sets

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Table 2. Demographic data of the participants (Mean ± Standard Deviation)

Variable	Group	Mean ± SD	t	p
Age (years)	MEP	60.1 ± 7.6	0.162	0.67
	Control	60.4 ± 8.2		
Height (cm)	MEP	161.3 ± 5.5	0.667	0.51
	Control	160.1 ± 4.6		
Weight (kg)	MEP	67.9 ± 8.8	0.670	0.41
	Control	68.5 ± 9.8		

Note: p < 0.05 was considered statistically significant.

Table 3. Mean ± SD distribution of study variables in two groups before and after internation

variable	Group	Pre-test Mean ± SD	Post-test Mean ± SD	Intergroup (t, P)	Between group (F, P, Eta)
Quality of life	MEP	105.68 ± 10.82	147.63 ± 13.82	t = 183.166 p < 0.001	F = 3161.964 p < 0.001 Eta = 0.99
	Control	104.41 ± 10.42	118.98 ± 12.52	t = 153.141 p < 0.001	
Static balance	MEP	5.62 ± 1.81	10.17 ± 4.12	t = 89.098 p < 0.001	F = 44.154 p < 0.001 Eta = 0.62
	Control	6.52 ± 2.41	5.98 ± 1.52	t = 33.816 p < 0.001	
Dynamic balance	MEP	14.68 ± 4.52	11.17 ± 3.82	t = 124.435 p < 0.001	F = 6.872 p < 0.01 Eta = 0.32
	Control	16.71 ± 5.42	16.25 ± 12.52	t = 46.073 p < 0.001	
Wrist strength	MEP	59.88 ± 14.62	77.27 ± 15.12	t = 18.965 p < 0.001	F = 3161.964 p < 0.001 Eta = 0.99
	Control	64.99 ± 15.31	66.24 ± 13.10	t = 0.390 p < 0.001	
Walking speed	MEP	12.61 ± 4.62	10.05 ± 4.12	t = 53.541 p < 0.001	F = 1861.706 p < 0.001 Eta = 0.98
	Control	12.44 ± 4.42	13.26 ± 5.52	t=8.692 P<0.001	

Dynamic balance

In the MEP group, the mean score improved significantly, decreasing from 14.68 ± 4.52 to 11.17 ± 3.82, indicating improvement (t = 124.435, p < 0.001). In contrast, the control group showed a slight improvement, with the score decreasing from 16.71 ± 5.42 to 16.25 ± 12.52 (t = 46.073, p < 0.001). The intergroup comparison revealed a moderate effect of the MEP (F = 6.872, p < 0.01, Eta = 0.32).

Wrist strength

The MEP group showed a significant increase in wrist strength with the mean score rising from 59.88 ± 14.62 to 77.27 ± 15.12 (t = 18.965, p < 0.001). In the control group, the mean score showed a slight increase from 64.99 ± 15.31 to 66.24 ± 13.10 (t = 0.390, p < 0.001). The intergroup comparison revealed a significant effect of the MEP (F = 3161.964, p < 0.001, Eta = 0.99).

Walking speed

In the MEP group, the mean score improved significantly from 12.61 ± 4.62 to 10.05 ± 4.12 (t = 53.541, p < 0.001). Conversely, The control group exhibited a slight decline in performance, with the mean score increasing from 12.44 ± 4.42 to 13.26 ± 5.52 (t = 8.692, p < 0.001). Intergroup analysis indicated a significant effect of MEP (F = 1861.706, p < 0.001, Eta = 0.98).

Discussion

According to the results of this study, after a 12-week training period, significant improvements were observed in quality of life, static balance, dynamic balance, wrist strength, and walking test performance in the MEP group. Furthermore, these improvements were more pronounced in the MEP group compared to the other groups after 12 weeks. The results of the present study indicated that after 12 weeks of training, static balance in the experimental group improved

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significantly compared to the control group. These findings are consistent with previous studies (25, 26). Alavi et al., demonstrated that both traditional Tai Chi and Pilates exercises have positive effects on balance improvement. However, considering the greater effect of Pilates exercises, it is recommended to incorporate this practice to improve balance and, ultimately, the quality of life in elderly men with PD (25). Nosrati et al., demonstrated that dynamic neuromuscular stabilization exercises can improve both static and dynamic balance in elderly individuals with PD. Based on these findings, it can be inferred that incorporating these exercises into rehabilitation programs could lead to improvements for people with PD (26). "MEP can enhance functional recovery of vestibular-ocular and vestibular-spinal reflexes, aiding in balance improvement by promoting coordination between the head, body, and eyes as they adapt to new movements."(27). The results of the present study showed that after 12 weeks of training, dynamic balance in the experimental group improved significantly compared to the control group. The results of the present study align with the findings of previous studies (24, 28). The improvements in balance following MEP can be attributed to increased neural adaptations, including the activation of more efficient neural units, reorganization within the somatic cortex, enhanced strength and efficiency of synaptic connections, greater nervous system activation, reduced inhibitory neural reflexes, and decreased resistance in neural pathways for impulse transmission (29). MEP, incorporating resistance, balance, and aerobic components, form a comprehensive exercise program that can significantly enhance both static and dynamic balance in Parkinson's patients. In contrast, previous studies that focused on each type of exercise individually showed less pronounced effects on the balance of Parkinson's patients (23).

The results of the present study demonstrated a significant improvement in muscle strength in the experimental group after 12 weeks of training, compared to the control group. These findings align with those of previous studies (30). The results of a study by Bambaeichi et al., (31) showed that 10 weeks of resistance and balance training significantly improved the strength of Parkinson's patients, so strength and balance training can be included in the treatment plan of this group of patients. Murakami et al., examined the characteristics of PD patients with sarcopenia in Japan, finding that calf circumference was the most useful tool for screening sarcopenia in PD. Handgrip strength and the Four-Square Step Testalso demonstrated high sensitivity, particularly in men (32). PD leads to tremors, reduced mobility, and impaired physical performance, causing individuals with PD to have lower strength compared to their age-matched peers. MEP that enhance deep receptors and muscle spindles have been shown to improve hand muscle strength in patients with PD (33). Combining resistance, balance, and aerobic exercises as a multimodal training program can enhance hand strength in Parkinson's patients. The combination of these exercises proved to be more effective in improving hand strength than individual exercises. The results of the present study showed that after 12 weeks of MEP, walking speed in the experimental group significantly improved compared to the control group. These findings are consistent with previous study (33). In chronological order, patients with PD experience difficulties when starting to walk. For instance, walking speed and stride length are abnormally reduced, and lower limb joint rotation is limited due to stiffness. Step timing becomes irregular and asymmetrical, and arm swing is either reduced or absent (34). Additionally, two common features are observed: gait impairment and awareness issues, including sudden acceleration as the patient attempts to maintain their center of gravity between their legs, compensating for a stooped posture. Freezing of gait is characterized by a sudden stop in the patient's walk, often accompanied by leg shaking and a sensation of being 'stuck' to the ground. These gait impairments can significantly reduce quality of life and increase the risk of falls. However, MEP have been shown to improve walking speed in Parkinson's patients (35). The results of the present study showed that after 12 weeks of training, the quality of life in the experimental group significantly improved compared to the control group. These findings are consistent with previous studies (33, 34). PD is a multidimensional condition, affecting various aspects of health and well-being, which makes interventions like the one in this study particularly valuable for improving patients' overall quality of life (36, 37). PD is a multidimensional condition that affects various aspects of patients' lives. To manage its complications, multifaceted approaches are often used, which include not only exercise but also complementary therapies. Movement therapy, in particular, plays a crucial role in improving patients' daily functioning. Research has demonstrated that balance training, as part of these approaches, significantly enhances both the function and quality of life of individuals with PD (37).

Conclusions

The results of this study suggest that MEP can significantly enhance quality of life, balance, walking speed, and hand strength in elderly individuals with PD. This underscores the potential of multimodal exercise programs—incorporating resistance, aerobic, and balance training—as an effective complementary therapeutic strategy for managing PD symptoms. However, further large-scale and longitudinal studies are needed to confirm these findings and assess their long-term effects. Integrating such exercise regimens into rehabilitation programs could offer substantial benefits for PD patients.

Study limitations

The study has several limitations. The relatively small sample size and the focus on female participants from a single city may limit the generalizability of the findings. Future research employing longitudinal designs, larger and more diverse sample populations,

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and extended intervention periods is recommended to validate and broaden these results.

Conflicts of interest

There are no conflicts of interest.

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Authors' contribution

KH.J and F.T and A.C contributed to the research methods.
KH.J has done supervision with of AA.N.
KH.J and MN.R has done data analysis.
AA.N and KH.J wrote the manuscript.
All authors read the manuscript and verified it.

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