Research Article

The effects of dynamic flamingo balance exercises and balance training with a Tetrax® posturography device on the balance performance and fall risk of patients with Parkinson's disease

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Abstract

Background: Balance disorder is more prevalent in patients with Parkinson's Disease (PD). This study aimed to examine the effects of flamingo balance exercises and balance training with Tetrax® Interactive Balance System (TIBS) (Sunlight Medical Ltd, Ramat Gan, Israel) on the balance performance and fall risk of patients with PD.

Methods: This randomized-controlled, single-blind, prospective study was performed at the Department of Physical Medicine and Rehabilitation, Istanbul Atakent Acıbadem Hospital, Turkey, between September 2022 and January 2023. One hundred twenty-four patients were randomly divided into four groups: (1) balance training group with TIBS ($n = 31$), (2) flamingo training group ($n = 32$), (3) combined training group ($n = 31$), and (4) control group ($n = 30$). All participants trained 3 days a week for 6 weeks, with patient-specific training. Trial groups were evaluated with pre-treatment and post-treatment.

Results: After the treatment, there was a statistically significant difference in all balance and fall scores in patients who received alternate balance training ($p < 0.05$). The balance and falling values in the combined training group were superior to single-type training groups ($p < 0.05$).

Conclusions: Dynamic flamingo therapy combined with balance exercises with a static posturography device improves balance disorder in PD patients compared to therapy restricted to individual training.

Keywords

Parkinson's Disease, balance disorder, dynamic flamingo therapy, combined balance therapy

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Introduction

Parkinson's disease (PD) is a common neurodegenerative disorder manifested clinically by bradykinesia, impaired gait and balance, restricted movement due to disrupted motor functions as well as neuropsychiatric symptoms including cognitive and behavioral changes, autonomic nervous system failure, sensory disturbances, and sleep problems.[1–3] The loss of dopaminergic neurons at the substantia nigra severs the signaling in the motor cortex and disrupts the movement ability.[1,2] PD is mainly idiopathic; only 20% of the cases are attributed to a particular mutation or genetic background.[4] Balance disorder in PD coincides with the combination of disorders such as loss of postural reflexes and postural adjustments, rigidity, and akinesia. Balance and gait impairment show a disease-specific pattern. Postural instability and gait disturbance often result in falls, causing severe injuries, and affect the life quality of patients significantly.[1,3,5]

Gait impairment and freezing increase with the progression of the disease and do not respond effectively to dopaminergic treatment.[6] Thus, combinatory treatment approaches

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based on balance and gait training were studied in the literature as a feasible option to improve motor functions in patients with PD.[6,7] Although studies provided strong evidence that conventional physiotherapy is effective in improving balance and gait, they noted some limitations regarding the benefits of the treatment.[8,9] Thus, clinically, gait and balance training did not make it to the traditional therapy approaches for PD.

During the progression of PD, the balance is impaired as postural stability decreases and rigidity increases. For this reason, dynamic and repetitive balance exercises are beneficial regimens to improve motor functions. Up-to-date, various balance training activities are available. Flamingo therapy, defined and named by Sakamoto et al., was inspired by the one-legged stance of a flamingo, used as both evaluation and training to boost balance and gait.[10,11] Tetrax® Interactive Balance System (TIBS) (Sunlight Medical Ltd, Ramat Gan, Israel) is an effective and reliable method for rehabilitating patients with balance disorders. The system evaluates balance among four platforms incorporated by heel and toe stability and the balance index and calculates the fall risk as a percentage (%).[12]

Studies on balance are precious in PD patients, as implementing alternative approaches to improve balance will directly reduce the patient's symptoms, such as restricted mobility and tremors. This study examined the effects of flamingo balance exercises and balance training with a TIBS device on the balance performance and fall risk of patients with PD. The study hypothesizes that TIBS device will be effective in developing balance and reducing the risk of falling.

Materials and methods

The study is a randomized controlled study. The study protocol was approved by the ethics committee of the relevant Acıbadem University Faculty of Medicine on 2022-14/04. This study was conducted following the principles of the Declaration of Helsinki, and all patients provided written informed consent before inclusion.

Study population

Patients admitted to the Department of Physical Therapy and Rehabilitation of Acıbadem University Atakent Hospital between September 2022 and January 2023 were included in the study. The patients who (a) between the ages of 40–75 and diagnosed with Parkinson's disease according to the UK Parkinson's Disease Brain Bank Association diagnostic criteria, (b) scored ≥24 at the Mini-Mental Test (have adequate cognitive function), (c) scored ≤2 at a modified Hoehn & Yahr Scale (mild to moderately affected by Parkinson's disease), (d) scored <52 at Berg Balance Scale (BBS) (mild to moderately affected in terms of balance disorder, (e) taking medication against PD for more than 3 weeks, (f) presented with normal cranial imaging, (g) were able to stand for at least 1 min, and (h) were able to walk at least 10 meters without support were included in the study (4). The patients who had neurological or psychiatric disorders other than PD, (b) had postural hypotension vision problems that cannot be compensated by the correct lens or (c) had vestibular disorders that may affect balance, having neurological, orthopedic, and cardiovascular diseases that impair walking and functional abilities other than PD, (d) history of surgery for PD (such as deep brain stimulation) and (e) participated in any physiotherapy program in the last 6 months were excluded. All patients were evaluated in the "on" period. Age, gender, body mass index (BMI), and age of onset of PD were recorded.

Study groups

Patients were randomly assigned into four groups: (1) Group 1, patients receiving balance training with TIBS (n = 31), (2) Group 2, patients who were receiving flamingo balance training (n = 32), (3) Group 3, patient who received combined training (n = 31), and (4) Group 4, control group without any functional training (n = 30). Each patient was given a sealed and numbered envelope outlining the details of the training procedure within it to achieve the random assignment of patients. An independent rater, except the assigned physiotherapist, blinded to the patient and group attributions, evaluated the balance performance before and after treatment. This study utilized high quality trial methodologies in accordance with CONSORT guidelines.

Balance training

Group 1. The patients in group 1 received static balance exercises for 20 min, 3 days a week, for 6 weeks, using only the TIBS. Three different balance exercise protocols were applied. The first exercise included catching the balls falling from the top of the computer screen with the baseball glove by transferring weight to the right and left on the balance platform. The second exercise incorporated 25% of patients' weight transfer to the A, B, C, and D balance plates on the balance platform. The third exercise improved the patient's balance by forcing them to stabilize their balance, keeping the red ball visible on the screen within the green circle by changing the pressure applied to his feet for 10 s.[12]

Group 2. Dynamic flamingo exercises were assigned to the patients in Group 2. Patients were asked to stand on one leg at a time for one minute, 3 times a day, without support from place/object. This exercise was repeated for both legs.[13]

Group 3. The patients in Group 3 received a combined exercise consisting of static balance training with the TIBS (20 min, 3 days a week, for 6 weeks) and dynamic flamingo exercises (3 times a day for one minute per leg) as described above.

Group 4. Patients in Group 4 did not receive any form of balance training. Their exercise regimen only included flexibility exercises, five days a week for six weeks. The sequence and the form of exercises were demonstrated visually via illustrated exercise forms. The follow -up period of the study is 6 weeks.

Evaluation of balance training effects

Patients were evaluated before and after the training (pre-treatment vs. post-treatment) with the BBS, single leg standing (SLS) test, 10 meters walking test, timed get up and go (TUG) test, Activity-Specific Balance Confidence Questionnaire (ABC), Modified Hoehn Yahr Scale, fall efficiency scale, Unified Parkinson's Disease Rating Scale (UPDRS) and TIBS in terms of the risk of falling.

Berg balance scale (BBS). The BBS evaluates the ability of patients to maintain their balance when doing their routine functional activities.[14] The scores of the BBS test were defined and recorded according to Şahin et al..[15]

Single leg standing scale (SLS). The SLS test evaluates the static balance by measuring the patient's standing time in balance on either the right or left leg at a time. The time between the moment the patient begins to stand on one leg and the first moment when postural stability is impaired was recorded. Values below 30 s indicate impaired balance. Especially in the elderly, at least 5 s on balance is expected.[16]

Ten meters walking test. Walking is an important indicator of patients' functional physical capacity. It is a reliable, simple, fast, and easy-to-apply method that can be used in balance disorders and estimation of falls. The test is completed when the person starts standing and walks a distance of 10 meters. Then the elapsed time is recorded.[17]

Timed get up and go (TUG). The TUG evaluates dynamic balance and functionality.[18] Briefly, patients were asked to stand up from the seating position without support (e.g., arms of the chair), walk 3 meters without support, return towards the chair, and sit down. The elapsed time was recorded. Reference values of the TUG test were as follows: 8.1 (7.1–9.0) sec for age 60–69; 9.2 (8.2–10.2) for age 70–79, 11.3 (10.0–12.7) sec for age 80–99.[18,19]

Activity-Specific balance confidence questionnaire (ABC). The ABC questionnaire involves 16 task-specific questions to determine performance-related balance assessment. The basis of the survey is the perception of patients on how confidently they can perform the six activities inside and outside the house, between 0 (unsafe) and 100 (completely confident).[20] An adapted version of the questionnaire is used in this study.[21]

Unified Parkinson's Disease rating scale (UPDRS). The UPDRS evaluates the severity of the disease, symptoms, and treatment complications in patients. In the motor evaluation section, the 14 were graded as 0 (no impairment) to 4 (the impairment is at the most severe level or unable) according to the severity of motor symptoms.[22] The scale has been shown to have Turkish validity and reliability.[23]

Modified Hoehn Yahr Scale. The Modified Hoehn and Yahr Scale (MHYS) is broadly used for staging PD in clinical examination, and its validity and reliability for Turkish patients have been demonstrated. The increase in the score indicates the advanced stage of the disease. The disease severity is evaluated between one and five stages. Stage one refers to the absence of signs of disease, and stage five refers to the most advanced stage, where the patient is bedridden.[24]

Fall Efficiency Scale- International (FES-I). The Fall Effectiveness Scale-International assesses patients' fear of falling during physical and social activities,[25] and its validity and reliability in the Turkish population were previously demonstrated.[26] The patient's fear of falling is evaluated with 16 questions, each with 4 categories of answers: 'not concerned', ' slightly concerned', 'concerned', and 'very concerned'. The total score ranges between 0 and 64. Increased scores indicate anxiety and fear.[25]

Tetrax® Interactive Balance System. The TIBS assesses the balance and fall risk. The system collects data from four platforms measuring vertical pressure fluctuations from both heels and toes. The fall risks were calculated as a percentage (%) with the posturographic program using the oscillation rates.[12]

Statistical analysis

Statistical analysis was performed using SPSS software (IBM SPSS Statistics, version 22.0), The p values <0.05 were statistically significant. Categorical variables were presented as frequency and/or percentage, whereas numerical variables were described as mean ± standard deviation (SD). Normality was analyzed with the Kolmogorov-Smirnov Test. Two groups of normally distributed data were compared using a t-test, where the Mann-Whitney U Test was used to compare the non-normally distributed data. The Kruskal Wallis Test compared data for more than three groups. The Mann-Whitney U Test was used as a further analysis test to determine which subset of groups

led to significance. Wilcoxon Signed Rank Test was used to analyze the effect of training among groups if the data did not fit with the normal distribution. The Chi-Square test was used to compare categorical data. The size of the minimum sample pool was calculated using the G-Power (ver. 3.1) software (95% confidence interval, 80% power, and 0.72 effect size) as 32 individuals (8 individuals in each group) (11).

Results

Hundred and forty-two PD patients were admitted to the Department of Physical Medicine and Rehabilitation. The patients who refused to be involved in the study (n = 4) and did not meet the inclusion criteria (n = 10) were excluded from the study. During follow-up (six week), 1 person from each group could not be reached. A total of 124 patients were randomly assigned to the groups where they received different types of balance training for 6 weeks. Group 1 received TIBS-guided balance training (n = 31), Group 2 received flamingo training (n = 32), Group 3 received a combination of flamingo and balance training (n = 31), and Group 4 only received stretching exercise regimens (n = 30) (Figure 1).

A total of 124 patients completed the six-week balance exercise program. All participants completed the entire training protocol without any adverse effects. Table 1 shows the sociodemographic and clinical characteristics of the patients. There were no significant differences between Group 1, Group 2, Group 3, and Group 4 with respect to the sociodemographic features in the baseline measurements ($p>0.05$). The pre-treatment clinical and balance parameters were comparable among groups ($p > 0.05$) (Table 2). The balance, flamingo, and combined training significantly improved balance and fall scores within each group ($p < 0.05$). In the control group, pre- and post-treatment balance and fall scores were comparable ($p > 0.05$). Interestingly, the combined training incorporating both balance and flamingo exercises was much more beneficial to the patients in improving balance disorder compared to the patients who only received individual types of training ($p < 0.05$) (Table 2).

Discussion

In the study, we focused on the effect of individual or combined static posturography and dynamic flamingo-based balance training on gait impairment in PD. Our findings show that combined balance exercises were more effective in improving balance and reducing fall risk. Older individuals have a higher risk of PD; the EUROPARKINSON study[27] emphasizes that the age intervals 65–70, 80–85, and over 85 are associated with the increased prevalence from 18% to 36% to 50%, respectively.[4] Cohort studies on parkinsonism noted that males were more prone to PD than females.[4,28] The patients included in our study were among the risk age, unlike the previous research, the gender ratio was 1:1. Although PD is idiopathic – only 20% of cases were associated with genetic background and/or mutation – the underlying reason of a gender difference is still unclear.[4]

Gait impairment and restricted movement are the early symptoms of PD.[29] The loss of more than % 50 of the dopaminergic neurons in the substantia nigra results in the disruption of the motor abilities.[30] Loss of motor abilities manifested as falls, which are the hallmarks of PD.[1] Except for medication, exercises were shown to strengthen the dopamine-independent, alternative pathways. Dance,[31] aerobic training,[32] and music[33] therapy restore and/or maintain motor and cognitive function. A type of aerobic training, cycling, improved thalamo-cortical-dependent motor connectivity in PD, where pedaling motion and the increased pedaling rate were associated with better connectivity.[34] The previous therapies, although they seem unconventional, were proven to be beneficial for both neuron-dependent impairment as well as non-motor abilities by improving patients' mood.[31,33]

A few studies focus on the effects of static and dynamic balance training incorporated into PD therapy. Theoretically, similar to the above unconventional exercises, balance exercises enhance motor abilities and improve balance.[35] Chang *et al.* described the benefits of static posturography exercise, a relatively shorter training time of 2 weeks. The BBS and fall index of PD patients who received static posturography training improved significantly compared to the control group.[36] Another study from Balcı et al., examining 4 cases, showed that static balance training with the TIBS boosts balance and reduces fall risk.[37]

Vestibular function and proprioception sense, and proper contraction of responsible muscle groups, especially the ipsilateral hip adductors and gluteus medius muscle, are required to maintain one-leg standing balance.[38] Flamingo exercise, or test, defines standing on one leg with or without eyes closed.[10] Flamingo training is used widely to assess the ability to balance in the elderly,[13] and prevent future osteoporosis and fractures.[10] The pioneering, 6-month-long study by Sakamoto et al. compared the flamingo exercise (n = 410) and non-exercise group (n = 455) in the healthy elder population. The data have shown that the elderly benefited from flamingo exercise, and falls were reduced significantly. However, the training did not prevent fractures.[13]

A specific type of training favors particular neural connections and improves certain abilities. An interesting study focusing on the effect of a 12-week Hatha yoga program on balance and gait impairment in PD found that the yoga program benefits the static balance but not the overall gait.[39] A meta-analysis review rated 24 types of exercise on postural impairment in PD. Although the resolution of the analysis is low, the study found that gait training,

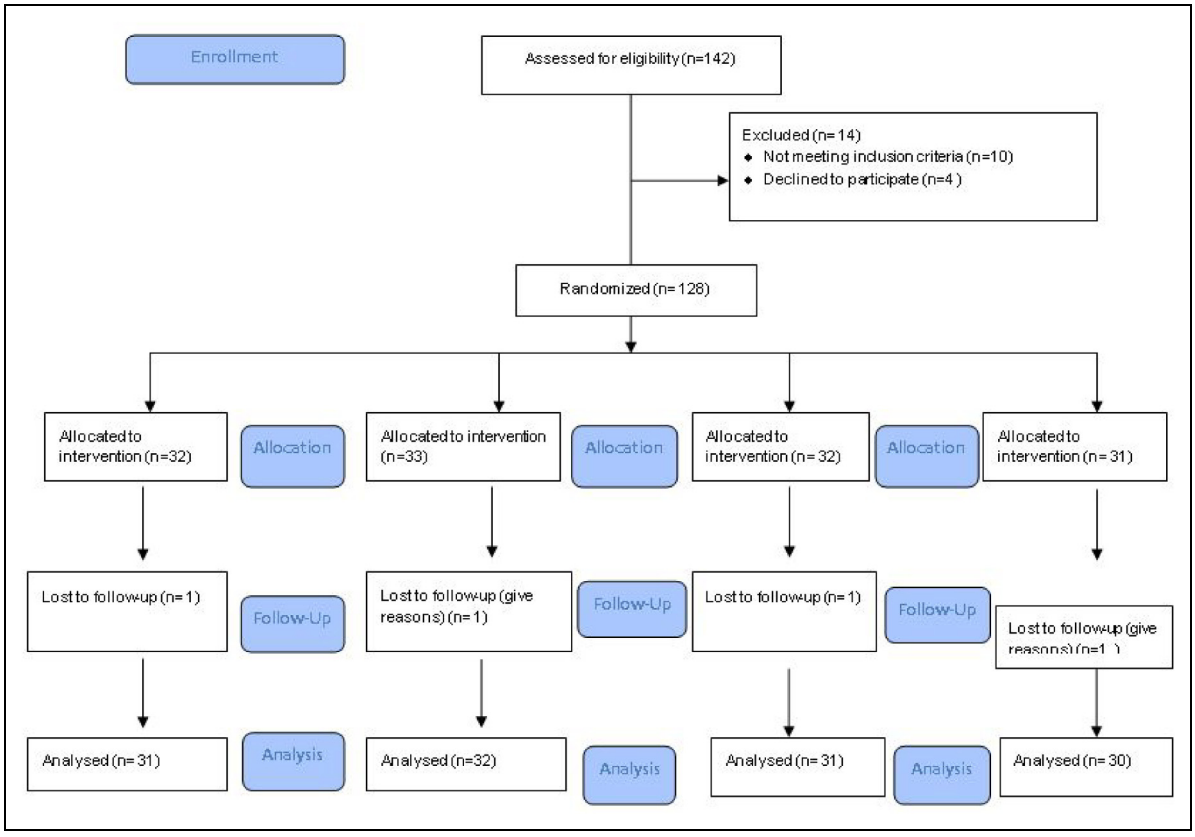

Figure 1. Flow diagram of the study.

treadmill exercise, Pilates, and aqua exercise are the most beneficial exercises for improving gait and balance.[40] Uzunkulaoğlu et al. examined the effect of Flamingo and KAT2000 balance devices on balance performance in patients with senile osteoarthritis. The study described that combined Flamingo therapy and KAT2000 exercise reduced the senile osteoarthritis-based balance impairment.[11] Overall, our findings, in line with the previous studies, show that alone flamingo or static posturography training reduces balance and gait impairment compared to the control group. We also showed that combined training is the most effective exercise modality for PD patients to reduce fall risk and improve balance-associated scores.

The time to perform the TUG test and the 10 m walking speed in all three groups significantly decreased. Dynamic flamingo therapy and TIBS are also observed to be effective in dynamic balance tests. Since these patients are in 2.5 and 3 according to the Modified Hoehn-Yahr stage, they define a mild disease. Schenkman et al., showed the TUG in PD patients, divided into H&Y staging, and their findings suggest that limitations in the TUG are not revealed until later in the disease progression, when fatigue and decreased muscle strength would predominate.[41] Significant improvement in dynamic balance tests may not be observed in advanced stages of Parkinson's disease as in our study.

Our study was composed of 4 clinical groups that received specific exercise regimens and a control, facilitating the interpretation of results. Additionally, the relatively homogenous distribution of the patients forming clinical groups with comparable, age, gender, and disease severity. Having 4 clinical groups with similar sociodemographic characteristics ensures the comparison cannot be biased by factors other than gait and balance. There are limitations in our study. The follow-up of the patients, a 6-week exercise period, does not allow us to predict long-term benefits. Regarding the study design, cases with additional medical conditions were excluded. The conditions might affect the tendency to fall; thus, eliminating such cases from the study might reduce the generalizability of the findings. One of the limitations of our study is that the study did not have a clinical trial registration. Since a few Parkinson's patients were included in the study after the ethics committee approval was obtained, the clinical trial registration was not applied and we did not want to change the patient data.

Although there are studies in the literature on balance exercises in Parkinson's patients, there are limited studies showing the benefits of Dynamic Flamingo Balance Exercises and TIBS on static and dynamic balance parameters in these patients. In our study, significant improvements were observed in balance parameters with 6-week

Table 1. Demographics and clinical characteristics of the patients.

Characteristics	Group 1 (n = 31)	Group 2 (n = 32)	Group 3 (n = 31)	Group 4 (n = 30)	*p*
Age (years), Mean ± SD	67.35 ± 4.23	66.35 ± 5.36	69.25 ± 3.87	68.24 ± 4.26	0.241
Gender (female/male)	16/16	15/18	15/17	15/16	0.465
Disease duration (months), Mean ± SD	50.35 ± 68.71	49.32 ± 47.56	51.65 ± 65.56	52.38 ± 64.15	0.534
BMI (kg/m^2), Mean ± SD	25.76 ± 3.32	24.13 ± 3.40	26.54 ± 2.34	25.16 ± 3.34	0.336
Education, n (%)					0.413
Primary school	8 (25.0)	11 (33.3)	8 (25.0)	8 (25.8)	
Secondary school	11 (34.3)	8 (24.2)	12 (37.5)	8 (25.8)	
High school	8 (25.0)	9 (27.3)	7 (21.9)	8 (25.8)	
University	5 (15.6)	5 (15.2)	5 (15.6)	7 (22.6)	
Employment, n (%)					0,422
Working in a paid job	7 (21.8)	2 (18.2)	8 (25.0)	6 (19.3)	
Not working	8 (25.0)	8 (24.3)	6 (18.8)	9 (29.1)	
Retired	17 (53.2)	19 (57.5)	18 (56.2)	16 (51.6)	
MHYS, n (%)					0.489
Stage 2.5	16 (50.0)	16 (48.4)	15 (46.8)	15 (48.4)	
Stage 3	16 (50.0)	17 (51.6)	17 (53.2)	16 (51.6)	

BMI: Body Mass Index, SD: Standard Deviation, MHYS: Modified Hoehn and Yahr Scale.

Table 2. Pre- and post-treatment changes in balance and fall risk between groups.

	Group 1 (n = 31)	**Group 2 (n = 32)**	**Group 3 (n = 31)**	**Group 4 (n = 30)**	***p***
BBS, Mean ± SD					
Before treatment	34.28 ± 5.30	33.48 ± 4.40	35.28 ± 6.10	34.41 ± 4.90	0.234
After treatment	44.98 ± 1.87	38.16 ± 2.03	51.28 ± 5.80	35.25 ± 6.10	
P	<0.001	<0.001	<0.001	0.233	
TUG (seconds), Mean ± SD					
Before treatment	13.80 ± 3.50	12.90 ± 3.90	12.70 ± 4.10	13.10 ± 3.40	0.512
After treatment	8.10 ± 2.60	10.40 ± 2.50	5.40 ± 2.30	12.10 ± 2.70	
P	<0.001	<0.001	<0.001	0.543	
SLS (seconds), Mean ± SD					
Before treatment	5.65 ± 3.36	6.29 ± 2.89	6.31 ± 3.23	5.95 ± 2.31	0.349
After treatment	11.23 ± 3.21	9.48 ± 2.54	19.73 ± 4.87	6.31 ± 1.98	
P	<0.001	<0.001	<0.001	0.487	
10 meters walking test (seconds), Mean ± SD					
Before treatment	23.38 ± 9.85	26.23 ± 10.65	25.48 ± 11.23	26.11 ± 9.29	0.217
After treatment	14.48 ± 6.32	21.24 ± 5.98	10.23 ± 4.32	27.12 ± 9.56	
P	<0.001	<0.001	<0.001	0.478	
ABC Scale, Mean ± SD					
Before treatment	58.53 ± 18.23	59.45 ± 16.34	61.02 ± 17.90	58.97 ± 16.82	0.198
After treatment	63.14 ± 16.35	60.98 ± 17.98	80.12 ± 19.21	59.67 ± 18.65	
P	<0.001	<0.001	<0.001	0.246	
UPDRS-Motor, Mean ± SD					
Before treatment	25.17 ± 8.33	23.87 ± 7.87	22.99 ± 9.98	24.76 ± 8.67	0.641
After treatment	14.34 ± 5.67	21.19 ± 5.43	9.18 ± 4.54	23.98 ± 9.12	
P	<0.001	<0.001	<0.001	0.348	
FES-I, Mean ± SD					
Before treatment	36.12 ± 7.60	35.23 ± 6.90	37.89 ± 7.1	36.09 ± 5.9	0.339
After treatment	27.18 ± 5.40	30.11 ± 4.90	23.89 ± 5.1	35.11 ± 6.1	
P	<0.001	<0.001	<0.001	0.554	
Fall risk (%), Mean ± SD					
Before treatment	88.23 + 15.67	91.43 ± 18.21	92.43 ± 16.28	88.98 ± 18.02	0.428
After treatment	56.12 ± 8.45	61.91 ± 7.23	34.89 ± 4.56	85.99 ± 17.19	
P	<0.001	<0.001	<0.001	0.467	

SD: Standard Deviation, BBS: Berg Balance Scale, TUG: Timed Up and Go, SLS: Single Leg Stance, ABC: Activities-Specific Balance Confidence, UPDRS: Unified Parkinson's Disease Rating Scale, FES-I: Fall Effectiveness Scale-International.

follow-up, and the long-term results of this effect are unclear. Future studies can be designed to observe the long-term effects of Dynamic Flamingo Balance Exercises and TIBS on balance and fall risk in Parkinson's disease patients.

Conclusion

Our findings represent that 6-week Flamingo balance exercises and balance programs with a static posturography device are effective in improving gait and balance impairment, balance confidence, and reducing the risk of falling during daily activities in patients with PD. Incorporating simple, cheap, and easy Flamingo balance exercises and balance training with a static posturography device that can be done in the hospital environment can contribute more to the development of balance. Performing flamingo balance exercises in home settings is also plausible and can be easily taught to patients who cannot always reach the hospital environment, and will be effective in reaching the goal.

Abbreviations

PD	Parkinson's disease
BMI	Body Mass Index
BBS	Berg Balance Scale
TUG	The timed up go
SLS	The single leg stance
ABC	Activity-specific balance confidence questionnaire
UPDRS	Unified Parkinson's Disease Rating Scale
MHYS	Modified Hoehn and Yahr Scale
SD	Standard deviation

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Statements and declarations

Ethical committee

Ethics committee of Acıbadem University Faculty of Medicine, the ethical approval number for the study is 2022-14/04.

Informed consent

Informed consent was obtained from all individual participants included in the study

Authors contributions

Sevil Karagül: Conceptualization, Writing-Original Draft, Data Curation.
Işıl Fazilet Kartaloğlu: Conceptualization.

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Declaration of conflicting interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Data availability

The data, code, and study material that support the fndings of this study are available from the corresponding author on reasonable request.

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