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Original Article

Change in Static Postural Stability after a Home-based Exercise Program in Persons with Idiopathic Parkinson's Disease - A Randomized Control Study

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Abstract

Introduction and Purpose: The most common form of parkinsonism is idiopathic Parkinson's disease. The cardinal symptoms of idiopathic Parkinson's disease are tremor, rigidity, bradykinesia, posture and gait abnormalities, speech changes, depression, gastrointestinal issues, urinary problems, autonomic features, eye abnormalities, cognitive impairments, cranial nerve dysfunction, and swallowing dysfunction. Abnormalities of posture significantly affect activities of daily living in such patients. Static posturography is used to measure the balance of an individual during standing. A single-blinded controlled trial comparing 4 weeks of outpatient physical therapy with no specific therapy showed significant improvement in gait in patients with Parkinson's disease. However, the gains were lost when the patients stopped exercises at the end of the program. Hence, the authors felt that teaching a simple, implementable home-based exercise could benefit these patients in improving their balance. Any change in static balance could be measured easily with a force platform.

Methodology: A total of 62 clinically diagnosed patients with idiopathic Parkinson's disease attending a tertiary care center were randomized into two groups, one rehabilitation group (those who were taught a simple home-based rehabilitation exercise program on an outpatient basis) and a non-rehabilitation (control) group who were not taught the exercises. They were clinically evaluated and their center of pressure (COP) sway area was measured using a computerized static posturography instrument (force platform), at first visit, after 1 month, after 3 months, and after 5 months. The differences in their COP sway area between the visits were compared between the two groups to see the change in postural stability.

Results and Discussion: A total of 62 patients who satisfied the inclusion criteria were inducted in the study after informed consent. The mean age of the rehabilitation group (n = 32) was 58.66 years and the mean age of the non-rehabilitation group (n = 30) was 59.17 years. 69% of the rehabilitation group were males and 31% were females, and in the non-rehabilitation group, 67% were males while 37% were females. The mean duration of disease in the rehabilitation group was 8.31 years and that in the non-rehabilitation group was 8.67 years. Most of the variables did not show any significant difference, and hence, the groups were comparable. The baseline mean COP sway area of the rehabilitation group was 76.53 mm^2 and that of the non-rehabilitation group was 76.73 mm^2. There was a 11.68% decrease in the COP sway area of the rehabilitation group at the end of the 1st month while the non-rehabilitation group had only 0.22% decrease. At the end of the study, i.e., at 5th month, there was a 32.05% decrease in the sway area from baseline in the rehabilitation group, indicating significant improvement in static balance. There was only 1.13% decrease in the sway area of the non-rehabilitation group. Both the P values were <0.001, and thus, our study revealed that a simple home-based rehabilitation exercise program taught on an outpatient basis to patients with idiopathic Parkinson's disease can improve the balance in such patients.

Conclusion: There was a statistically significant improvement in the static postural stability of patients with idiopathic Parkinson's disease who did exercise at home when compared to those who did not perform the home-based exercises. However, long-term studies need to be done to confirm whether this gain is long lasting.

Key words: Balance, Center of pressure, Home-based exercise, Idiopathic Parkinson's disease, Postural stability, Posturography, Rehabilitation

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INTRODUCTION AND RATIONALE

Parkinson's disease is a progressive disease of the nervous system marked by tremor, muscular rigidity, and slow imprecise movement, chiefly affecting middle-aged and elderly people. It is associated with degeneration of the basal ganglia of the brain and a deficiency of the neurotransmitter dopamine.[1]

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Parkinson's disease is now classified into three categories: Idiopathic, secondary parkinsonism, and parkinsonism plus syndrome. The most common form of parkinsonism is idiopathic Parkinson's disease. The cardinal symptoms of idiopathic Parkinson disease are tremor, rigidity, bradykinesia, posture and gait abnormalities, speech changes, depression, gastrointestinal issues, urinary problems, autonomic features, eye abnormalities, cognitive impairments, cranial nerve dysfunction, and swallowing dysfunction. The hallmarks of the pathology in Parkinson's disease are the loss of at least 60% dopaminergic neurons and the presence of Lewy bodies in surviving neurons of the substantia nigra. According to De Michele *et al*., the most relevant risk factor was a history of familial Parkinson's disease, and 33% of patients had at least one affected relative.[2] The symptomatic phase of Parkinson's disease has been correlated with 60–85% loss of dopaminergic neurons. Gait in Parkinson's disease is abnormal. This results from hypokinesia, rigidity, as well as defects of posture and equilibrium.[3] The gait components of the patients which related systematically to the degree of disability were step lengths, vertical excursions of the head, and extension of the hip and knee of the backward-directed limb at the onset of contralateral weight bearing.[4] Gait is characterized by small steps, shuffling gait pattern with the absence of arm swings. The patient leans forward and takes faster steps to catch up with his or her center of gravity.

Normal individuals when faced with balance perturbations such as environment or support surface changes activate fast and appropriate postural corrective responses to prevent a fall. Various central, neural, and motor systems work together to generate these responses. Age-related changes in the neural, sensory, and musculoskeletal systems can lead to balance impairments that have a tremendous impact on the ability to move about safely. Many complex substrates of the posture control system subserve a common functional goal: Regulation of the relationship between the center of mass (COM) and the base of support (BOS).[5]

Effective integration of sensory information about the visuospatial environment and body and limb position is essential for postural control. For example, standing posture is affected by perturbations to visual, vestibular, and proprioceptive sensory system.[6-8] The central nervous system (CNS) apparently uses a "sensory–reweighting" strategy when integrating sensory channels for postural control. The tendency to step in response to externally applied disturbances to stance appears to be a complex function of direction, velocity, displacement, and inertial load.[9]

The specific role of basal ganglia in postural control is complex and is only beginning to be unravelled. The basal ganglia are believed to be involved in various aspects of postural control.

1. Sensory channel integration.
2. Selection of automatic postural reactions.
3. Motor control flexibility and adaptability.
4. Regulation of muscle tone.
5. Modulation of the impact of cognitive factors on balance and gait (e.g., attention, multitasking knowledge, expectation of a potential perturbation, and fear of falling).[10]

In human standing, balance is continuously challenged by the force of gravity, perturbations due to voluntary movement, and changes in the environment. Regardless of the nature of perturbation, a basic requirement for stable upright stance is to maintain the body's COM within the boundaries of BOS, established by the feet (or hands when touching an object for support). Accordingly, COM location relative to the BOS is a critical variable that is controlled by the CNS in maintaining an upright stance. Maintaining balance involves regulating the static and dynamic relationship between COM and BOS.[11]

Measuring the center of pressure (COP) using a static posturography platform can objectively determine the static balance of a person who is standing. It can be measured either by measuring the length of sway trace (i.e., the pathway the COP moves in a fixed time) or the area of the COP sway for a fixed time.

Posturography is the general term that covers techniques used to quantify postural control in an upright stance, in either static or dynamic conditions.

Static posturography is carried out by placing the patient in a standing posture on a fixed platform (force plate), which is connected to a pressure detector or transducer. A computer integrates the results and produces detailed graphics and reports, which can then be compared with previous reports or with normative data.

Postural instability is a common feature of idiopathic Parkinson's disease, usually occurring in the late and advanced stages of the disease. Alterations in postural control have been documented during standing tasks or when performing voluntary movements.[8]

Multiple studies have attempted to improve abnormal gait features and balance of patients with Parkinson's disease using physical therapy and exercise.[12]

Postural control, stabilization, balancing activities, and weight shifting to counter changes in the center of gravity and eliciting righting reflexes have been tried. Encouraging

arm swinging, changes in movement direction, stopping and starting, addition of extrasensory cues such as tactile, auditory, and visual have also been studied. Thus, other on-going movements have an influence on the control of stability.[13] Comella *et al.* did a controlled trial of physical therapy - 1 h a day and 3 times a week for 4 weeks for persons with Parkinson's disease, which showed statistically significant improvements in gait and posture. However, at the end of the program when the subjects stopped exercising and when assessment was done at 6 months, it revealed loss of all gains.[14] A study by Palmer *et al.*[15] compared United Parkinson's Disease Foundation exercise program to an upper-body karate program. This study showed that both the groups had improvement in most physical parameters except whole-body coordination. The study concluded that exercise program is a useful adjunct to pharmacological therapy.

Hence, the authors were of the opinion that a self-supervised home-based program would be more convenient, practical, and less expensive to administer from the outpatient clinic than a continuous long-term hospital-based therapy program to improve the balance of such patients. This study attempts to record the changes in balance by measuring the COP using a computerized static posturography platform following a home-based rehabilitation exercise program in patients with idiopathic Parkinson's disease. Hence, the objective of this study was to assess the change in postural stability (balance) in patients with idiopathic Parkinson's disease after a home-based rehabilitation exercise program using COP area estimation.

Study Design

This was a prospective randomized control study.

Duration of the study

The period of the study was 1 year.

Study setting

The study was conducted at the Outpatient Clinic of the Department of Physical Medicine and Rehabilitation, Government Medical College, Thiruvananthapuram, and Movement Disorder Clinic of Sree Chitra Tirunal Institute of Medical Sciences and Technology.

Study population

Clinically diagnosed patients with idiopathic Parkinson's disease attending the outpatient clinics of the above departments were selected for the study.

Inclusion Criteria

The following criteria were included in the study:

1. Patients who were clinically diagnosed to have idiopathic Parkinson's disease who are ambulant with or without support (Hoehn and Yahr staging 1–3).
2. Both sexes.
3. Patients above 40 years.
4. Patients who are stable on drug therapy for 1 month before the start of the study.
5. Those who were willing to take part and give informed consent.

Exclusion Criteria

The following criteria were excluded from the study:

1. Patients with unstable cardiac status.
2. Patients with secondary parkinsonism, parkinsonism plus syndrome, and other movement disorders.
3. Patients with cerebellar or labyrinthine or visual dysfunction.
4. Patients who underwent surgery for the same disease.
5. Those with peripheral neuropathy as assessed clinically.
6. Current psychiatric or neurologic disorders.
7. Patients with a history of hallucinations or on antipsychotic treatment.
8. Patients with a history of seizure disorder or vasovagal syncope.

Sample Size

Patients were divided into two groups based on simple random sampling: Those receiving home-based rehabilitation exercises (study or rehabilitation group $n=32$) and those that did not (control or non-rehabilitation group $n = 30$).

Ethical issues

The study was conducted after the Institutional Ethical Committee approval. Those patients who had given informed consent were included in the study. Patients continued with their standard treatments.

METHODOLOGY

Patients who attended the clinics and were diagnosed clinically with idiopathic Parkinson's disease, who met the above criteria, and who were willing to give informed consent were included in the study.

They underwent detailed clinical evaluation and COP measurements using a computerized static posturography instrument (Stabilo by Infotronic). The patients were grouped into two groups, rehabilitation group who were given exercise program and non-rehabilitation (control) group who were not given the exercise program, using convenient simple random sampling. Further, the two groups continued their standard treatment including drugs and other supportive measures.

The rehabilitation group was inducted into a simple home-based rehabilitation exercise program which was taught to the patient and caregiver on an outpatient basis. The non- rehabilitation or control group was not given such training.

Outcome Measure

The measurement of balance was done by plotting the COP on a computerized static posturography instrument (Stabilo by Infotronic). The force platform on which the patient stood to measure the COP sway area consisted of a static platform with force transducers underneath it. The force platform was connected to a computer which displayed the COP sway on the screen. The area of the COP sway on X- and Y-axis was measured in mm^2 and was considered as the measure of static balance. More the area means, more the sway and less the balance.

Procedure

The patient was asked to stand on the force platform with eyes open, and the foot size was measured and entered into the computer for calibration. The patient was asked to stand straight with hands on the side and looking straight ahead. The reading was taken for 20 s, and the area of COP sway in the X- and Y-axis measured in mm^2 was taken as the COP value.

The outcome measure was done at baseline (1st visit), 3rd month (2nd visit), and 5th month (3rd visit).

Intervention

The intervention for the rehabilitation group included a simple home-based rehabilitation exercise program which was taught on an outpatient basis for 2 days and the patient was asked to continue the same at home.

The program included:

1. Education about the disease and the importance of exercise to the patient and caregiver.
2. After the counseling, the patient and caregiver were asked to return in 2 days when they were taught a supervised exercise program of 30 min for 2 days on an outpatient basis.
3. Basic bedside exercises were taught to the patient and caregiver.
4. Specific exercises to improve posture, balance, walking, and turning were taught.
5. Pre-activities of daily living were explained.

The patients were asked to perform the exercises during the "on" state of the disease in the morning for ½ h for 5 days a week. They were given hand-outs.

At each follow-up visit, the caregiver and patient were given psychosocial counseling about coping, difficulties, and behavior issues along with encouragement to continue the home-based exercises.

Clinical evaluation and COP measurements were done. The patient continued their regular checkups with their physician and neurologist.

The caregiver and patient of the control or non-rehabilitation group were only given counselling and education at each visit. The control group was not trained on the specific exercise program. However, during the follow-up visits, they were clinically evaluated and their COP sway area measured like that for the rehabilitation group. Both groups continued their standard treatment prescribed by their physician or neurologist.

Analysis

The data collected were statistically analyzed using SPSS software. The calculations were done separately for the rehabilitation group ($n = 32$) and non-rehabilitation group ($n = 30$). The age, sex, and side involved were compared using Chi-square test and *t*-tests. The difference between baseline and subsequent follow-ups of COP area in mm^2 was analyzed using independent sample two-tailed *t*-test for the equality of variance.

RESULTS AND OBSERVATION

The study included a total of 62 patients with idiopathic Parkinson's disease who were divided into two groups by random sampling: The rehabilitation group ($n = 32$) and the non-rehabilitation or control group ($n = 30$) [Table 1]. The mean age of the rehabilitation group was 58.66 ± 7.87 years (mean ± standard deviation) and that of the control group was 59.17 ± 8.37 years [Figure 1]. There was no significant difference between the groups (*t*-value=0.247, $P = 0.813$), and hence, the groups were comparable.

When considering gender, 69% of the rehabilitation group were males and 31% were females [Table 2]. In the non-rehabilitation or control group, 67% were males and 33% were females [Figure 2] (Chi-square = 0.203, $P = 0.789$). The groups were comparable as there was no significant difference between them.

Considering laterality of the disease, 53% of the rehabilitation group had unilateral symptoms and 47% had bilateral involvement, while, in the non-rehabilitation group, 50% had unilaterality and the other 50% had bilaterality [Table 3] (Chi-square = 1.552 $P = 0.213$). Since there was no significant difference, both groups were comparable.

Considering the duration of the disease in the study population, the mean duration of the disease in the study

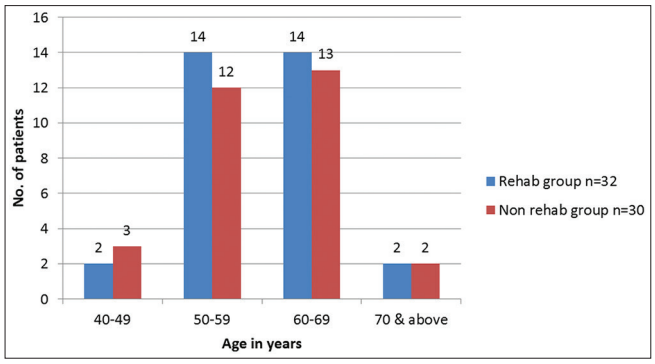

Figure 1: Age distribution

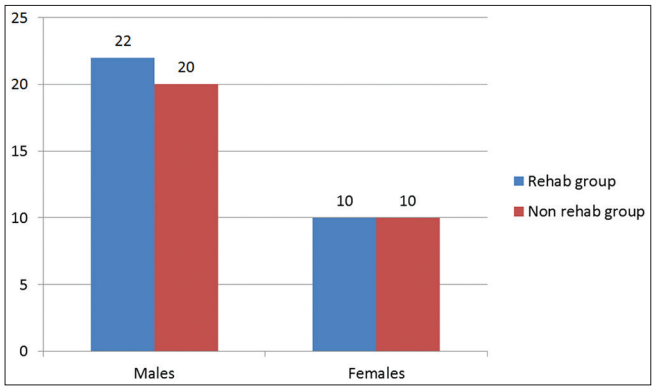

Figure 2: Distribution of gender - bar chart

Table 1: Distribution of age

Age range (years)	Rehabilitation group, *n*=32	Non-rehabilitation group, *n*=30	Total
40–49	2	3	5
50–59	14	12	26
60–69	14	13	27
70 and above	2	2	4
Total (*n*)	32	30	62

Table 2: Distribution of gender

Gender	Rehabilitation group	Non-rehabilitation group	Total
Males	22	20	42
Females	10	10	20
Total (*n*)	32	30	62

group (rehab) was 8.31 ± 3.52 years, and in the non-rehabilitation group, it was 8.67 ± 3.14 years [Figure 3] (*t*-value = 0.417 *P* = 0.988). 62% of the rehabilitation group had the disease for 6–9 years and 60% of the non-rehabilitation group had the disease for 6–9 years [Table 4].

Comparison of the mean of difference in subsequent follow-up of COP sway area measurements at baseline, 1st month, 3rd month, and 5th month revealed the following [Figure 4].

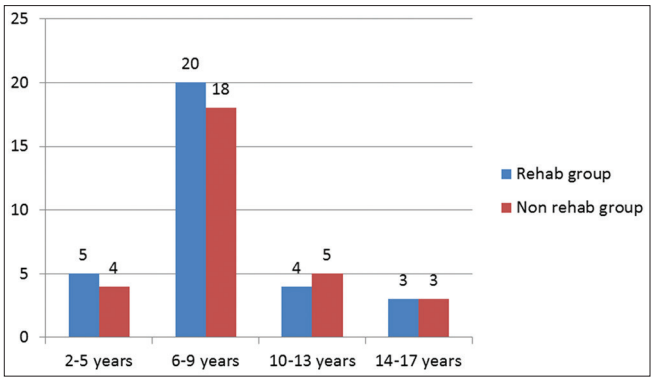

Figure 3: Distribution of duration of disease in years

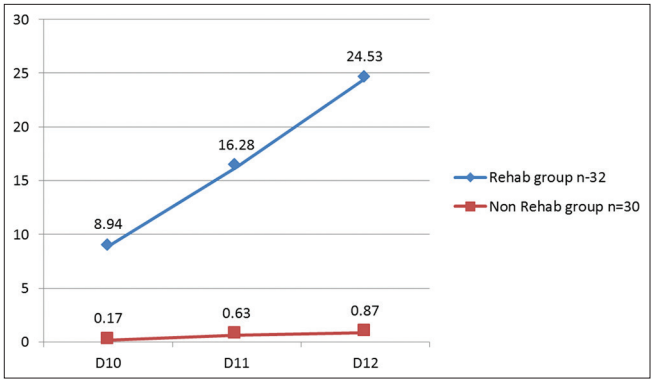

Figure 4: Comparison of the mean of difference in centre of pressure sway area between subsequent visits

Table 3: Distribution of sides involved

Laterality	Rehabilitation group	Non-rehabilitation group	Total
Unilateral	15	15	30
Bilateral	17	15	32
Total (*n*)	32	30	62

Table 4: Distribution of duration of disease in years

Years of disease	Rehabilitation group	Non-rehabilitation group	Total
2–5	5	4	9
6–9	20	18	38
10–13	4	5	9
14–17	3	3	6
Total (*n*)	32	30	62

The mean COP sway area in mm^2 of the rehabilitation group (n = 32) was 76.53 mm^2 and that of the non-rehabilitation group (n = 30) was 76.73 mm^2.

There was a 11.68% decrease in sway area which means improvement in balance from the baseline to second visit in the rehabilitation group which was statistically significant ($P < 0.001$); however, although the non-rehabilitation

Table 5: Comparison of the mean of difference in COP sway area between subsequent visits

Difference in COP	Rehabilitation group, *n*=32 mm² (%)	Non-rehabilitation group, *n*=30 mm² (%)	*P* value	*t*-value
D10	−8.94 (11.68)	−0.17 (0.22)	<0.001	10.399
D11	−16.28 (21.27)	−0.63 (0.82)	<0.001	13.365
D12	−24.53 (32.05)	−0.87 (1.13)	<0.001	14.191

D10: Difference in COP area between 1st visit and 2nd visit (1 month), D11: Difference in COP area between 1st visit and 3rd visit (3 months), D12: Difference in COP area between 1st visit and 4th visit (5 months), COP: Center of pressure

group showed statistically significant improvement, the percentage change was only 0.22%. Similarly, the COP sway area measurement showed 21.27% decrease from the baseline to the third visit in the rehabilitation group, whereas the non-rehabilitation group showed 0.82% decrease only.

The overall decrease in COP sway area was 32.05% for the rehabilitation group, while it was 1.13% in the non-rehabilitation group. A decrease in the sway area means improvement in postural stability or static balance (negative values as shown in Table 5).

DISCUSSION

The purpose of the study was to measure the change in static postural stability (balance) in patients with idiopathic Parkinson's disease after a home-based rehabilitation exercise program. The main outcome measured to assess the static postural stability (balance) was COP sway area in mm². The study involved two groups: One rehabilitation group who received the home-based exercise program and the non-rehabilitation group who did not. The rehabilitation group had 32 patients and the non-rehabilitation group had 30 patients. The mean age of the study group was 58.66 years and that of the control group was 59.17 years. The mean duration of disease was 8.31 years and 8.67 years in the study and control groups, respectively. Since *P* values were high in the variables, there was no significant difference between the groups, and hence, the groups were comparable.

Statistical analysis with independent sample two-tailed *t*-test for equality of variance was performed on the difference in COP sway area in mm² between subsequent follow-up visits. This revealed a statistically significant difference between both the rehabilitation and non-rehabilitation groups. There was 11.68% improvement in balance during the first follow-up in the rehabilitation group, whereas the non-rehabilitation group had an improvement of 0.22% by the first follow-up, both of which were statistically significant ($P < 0.001$). There was an improvement of 21.27% by the 3rd month in the rehabilitation group and an improvement of 0.82% in the non-rehabilitation group when compared with baseline values. There was an overall improvement of 32.05% by the 5th month in the rehabilitation group and an improvement of 1.13% in the non-rehabilitation group, indicating a significant improvement of about 30% in the static balance of patients with idiopathic Parkinson's disease who followed a home-based rehabilitation exercise program.

Comella *et al*.[14] conducted a randomized, single-blinded, crossover study of outpatient physical therapy for 4 weeks in patients with Parkinson's disease and a control group who received no specific therapy. They concluded that, at the end of 4 weeks of therapy, the posture and gait scores as measured by UPDRS showed significant improvement in postural stability ($P < 0.001$). However, at the end of the program, the patients stopped exercising. At 6-month follow-up, reassessment revealed loss of gains. Hence, continuation of exercise is necessary for sustaining postural stability.

A study by Palmer *et al*.[15] compared a United Parkinsonism Disease Foundation exercise program to an upper-body karate program. The study concluded that an exercise program was a useful adjunct to pharmacotherapy.

A study by Gauthier *et al*.[16] similarly revealed improvement in gait and posture ratings ($P < 0.05$) in patients with Parkinson's disease. Our study also showed significant improvement in static balance in patients with idiopathic Parkinson's disease who continued a home-based rehabilitation exercise program. A review article by Lauzé, *et al*., which studied 106 papers showed that physical activity seems most effective in improving physical and cognitive functional capabilities but was less effective for the symptoms of Parkinson's disease.[17]

Limitations of the Study

The sample sizes of the groups were small. The process of blinding was not part of the study. The study was done from a tertiary care setting. Long-term follow-up studies need to be done to assess whether these gains sustain in the long term.

CONCLUSION

Specific home-based simple rehabilitation exercise program can improve the static postural stability in patients with idiopathic Parkinson's disease when combined with drugs and supportive treatment.

Other Interest

This original article is part of the unpublished thesis of the first author Hemalata for her MD postgraduate course in PMR.

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