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# A Selective Corrective Exercise to Decrease Falling and Improve Functional Balance in Idiopathic Parkinson's Disease

Parisa Sedaghati,[1] Hassan Daneshmandi,[1,*] Noureddin Karimi,[2] and Amir-Hossein Barati[3]

[1]Department of Sport Injuries and Corrective Exercise , University of Guilan, Rasht, IR Iran
[2]Department of Physical Therapy, University of Social Welfare and Rehabilitation Sciences, Tehran, IR Iran
[3]Department of Exercise Physiologies, Shahid Rajaee Teacher Training University, Tehran, IR Iran

*Corresponding author: Hassan Daneshmandi, Department of Sport Injuries and Corrective Exercise, University of Guilan, Rasht, IR Iran. Tel: +98-7644433661, Fax: +98-7644433661, E-mail: daneshmandi_ph@yahoo.com

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**Abstract**

**Background:** Posture instability and unsteady gait disorders in Parkinson's Disease (PD) usually contribute to fall-related fractures. Fall-related trauma in PD is the most common reason for injury. Despite providing modern care for PD patients (PP) in the recent years, anti-PD drugs have no effect on falling. There is an urgent need to administer exercise interventions to reduce falls and related injuries in the rehabilitation program of PP.

**Objectives:** To explore the effect of a selective 10-week corrective exercise with an emphasis on gait training activities (GTA) on the number of falls (NOFs), fear of falling, functional balance, timed up and go (TUG) test among PD patients.

**Patients and Methods:** A purposeful sampling was performed on PP who had fallen or were at risk of falling in 2014. The study intervention consisted of a 10-week (3 sessions each week, each lasting 60 min) corrective exercise program. Participants were randomly allocated to control and two exercise groups; the exercise group with balance pad (EGBP) or exercise group with no balance pad (EGNBP). The analysis of variance (ANOVA) and paired t-test were used for comparison between the groups ($P \leq 0.05$).

**Results:** Administrating a selective corrective exercise in exercise group with balance pad (EGBP) showed a significant difference in number of falls (NOF), Fall Efficacy Scale-international (FES-I), Berg balance scale (BBS) (and timed up and go) TUG ($P = 0.001$); while administrating the same exercise in exercise group with no balance pad (EGNBP) showed no significant difference in NOF ($P = 0.225$) and a significant difference in FES-I ($P = 0.031$), BBS ($P = 0.047$) and TUG ($P = 0.012$). The control group showed no significant difference in each of the dependent variables.

**Conclusions:** Performing a selective corrective exercise on balance pad improves falling and functional balance in idiopathic PD.

*Keywords:* PD, Falling, Postural Balance, Exercise Therapy



## 1. Background

Falling-related trauma in elderly patients is the most common reason for injury and mortality (1). Falling is considered as the main concern in Parkinson's Disease (PD). Reportedly near two-thirds of PD patients (PP) have a yearly history of falling with half of them with a repeated history of falling (2). Injury and falling-related fears as the outcomes of PD (3-6) are common in sedentary lifestyles (6, 7) aggravating the tension in caring of such patients (8, 9). An estimated number of 5 million patients have PD in only ten populated countries, which may be doubled for next three decades (10). In spite of providing modern caring system in the recent years, anti-PD drugs had no effect on falling (11, 12). Hence, falling due to PD imposes a heavy cost of caring and rehabilitation in the following years.

Considering scarcity of literature, the effects of exercise on falling in PP were evaluated (12, 13). Ashburn et al. (2007) on their short-term exercise protocol reported an improvement in falling (12).

In general, significant effects of exercise are assessed in chronic exercise protocols (tens of hours to months) (14, 15).

The established risk factors for falling in PD are lower extremity muscular weakness, poor balance and gait freezing (16), all of which improve in PD following some exercise (12, 17-21). According to Latt (22) a series of factors are considered as risk factors for falling in PP (e.g., bradykinesia, poor balance, freezing of gait, cognitive impairment as well as age-related impairments, such as reduced lower limb muscle strength). For this reason, designing a corrective exercise to reduce falling to some extent would be targeted to partially recover the balance and lower limb muscle strength. Accordingly, an exercise program for improving falling in PD may be of benefit.

## 2. Objectives

Given beneficial effects of exercise in alleviating locomotor problems of PD and that performing corrective exercise may be effective we sought to assess the effects of exercise to see whether performing a selective 10-week corrective exercise with an emphasis on gait training activities (GTA) lessens the number of falls (NOFs) and fear of falling using the Fall Efficacy Scale-international (FES-I), functional balance in Berg balance scale (BBS), and the Timed Up and Go (TUG) test among PP.

## 3. Patients and Methods

### 3.1. Study Design

The sampling was made based on a purposeful method. Participants were voluntarily recruited from university affiliated neurology clinics and private neurology offices in Kashan. This study consisted of a 10-week (3 sessions per week, each lasting 60 min) corrective exercise for PP who had fallen or were at risk of falling conducted in 2014. After baseline assessment, participants were randomly allocated to control and two exercise groups. The sample size for participants in each group was based on similar studies (23).

The exercise groups were exercise group with balance pad (Exercise Group with Balance Pad [EGBP (no: 15)]) or without a balance pad (Exercise Group with no Balance Pad [EGNBP (no: 15)]). One participant of the EGNBP group dropped out of the study.

The control group (no: 17) received their usual care by a neurologist. Two participants in the control group dropped out of the study.

Cognitive function assessment with Mini-Mental State Examination (MMSE) was conducted one hour after participant's last dose of anti-PD drug.

### 3.2. Participants

At the start of study, all participants were sequentially screened by a neurologist. Medical assessment was performed to assess whether he or she is able to participate in moderate-intensity wholly-supervised exercise (an MMSE score of > 24) before enrollment in the study. A total of 47 (33 M, 14 F) participants in the second and third stages of the disease were selected based on Hoehn and Yahr criteria (24).

Participants were included in the study if had a diagnosis of idiopathic PD for three years and were able to walk independently, aged between 50 and 70 years, consumed the same anti-PD medication for past 2 weeks and had a history of falling in the past year. Participants were excluded from the study if had significant cognitive impairment (MMSE < 24 (25) or other neurological/musculoskeletal/cardiopulmonary/metabolic conditions that would interfere with safe conduction of training or exercise program.

Background information, including medical history, prescribed medications, age, height, weight, body mass index (BMI), falling history, FES-I, BBS and TUG test were recorded for all participants (Table 1).

All participants underwent two measurements namely one on entry to the study (pre-test) and one after a 10-week follow-up intervention (post-test).

### 3.3. Patient Assessment

All participants were evaluated for the following measurements in both pre-test and post-test.

i) Falls measured as the primary outcome of the disease assessed by comparing the number of falls (NOFs) between the study and control groups. The NOFs were recorded by direct questioning. ii) FES-I: a fall efficacy questionnaire denoting the fear of falling (26). iii) The BBS used for assessing functional balance of participants (27), consisted of 14 items assessing the capability to keep balance in different positions/postures. Scoring was based on participant's ability to do the tasks on a four-score system from 0 (inability in performing) to 4 (normal performance). The higher the acquired scores, the better the participant's balance. BBS was used for routine clinical and research applications as a balance measure, especially in PD (28, 29). iv) The TUG test used for assessment of balance and falling was defined as the time taken for performing a complex task (e.g. a sequential action: standing up from a chair with no arms and 45 cm height from the ground, walking 3 m, turning 180°, returning and sitting down (30). Three practice trials for each test were performed of which the mean of the recorded time was recorded as TUG.

### 3.4. Exercise Protocol

The exercise protocol undertaken for balance included a 60-min program of progressive balance and GTA 3 times a week for 10 weeks (31).

All exercise sessions included 5 minutes warm-up exercises followed by the main exercises for 50 minutes. The warm-up consisted of lower extremity stretch muscle groups, which act to prevent collapse of the lower limb (hip and knee extensors and ankle plantar flexors) targeted with exercises designed to enhance posture control (i.e. balance) with an emphasis on GTA. The balance exercises were included standing with a decreased base of support, forwards, backwards and sideway leg raise, and graded reaching activities in standing sit-to-stand, forward or lateral step-ups, semi squats and heel raises in standing as well. GTA included forwards, backwards and sideways stepping/walking, static and dynamic marching and tandem walking. Standard principles governing frequency, volume, duration, intensity and progression of exercises were applied (32). The exercise sessions were terminated with 5 minutes cool-down exercise. In both exercise groups, the same training protocol was performed. While, in EGBP all exercises were performed for 4 weeks and then for another 6 weeks using different balance pad sizes (6, 10 cm thickness, AIREX mat, Switzerland [(L) 93 cm × (B) 41 cm × (H) 10 cm); (L) 98 cm × (B) 41 cm × (H) 6 cm], respectively. The control group performed no training during the study period.

### 3.5. Ethical Considerations

This study was registered in the Iranian Registry for Clinical Trial (IRCT) as 2013032712865N1. They were briefed on the study aims and signed a written informed consent before enrollment. For safety purposes, the participants were instructed how to perform exercises safely with stable supports (such as a table) located nearby for additional support if required.

### 3.6. Data Analysis

The analysis of variance (ANOVA) was used for comparison of differences in personal characteristics, NOF, FES-I, BBS, TUG, between the three groups. Paired t-test was used for NOF, FES-I, BBS and TUG measures in all the three groups. Data analysis was performed using SPSS software version 16. A P-value less than 0.05 was assumed to be significant.

## 4. Results

### 4.1. Demographic Data of the Participants

Table 1 shows no significant difference regarding demographic variables between the groups.

### 4.2. The Effect of a Selective Corrective Exercise on NOF in EGBP and EGNBP Compared to Control Group

A selective corrective exercise on a balance pad in EGBP showed a significant difference in NOF between pre-test and post-test ($P < 0.001$). However, administrating the same exercise without a balance pad in EGNBP showed no significant difference; it caused a 33.3% decrease in falling rate. No significant change was seen in the control group (Table 2).

### 4.3. The Effect of a Selective Corrective Exercise on FES-I in EGBP and EGNBP Compared to Control Group

A selective corrective exercise in both EGBP and EGNBP (Table 2) showed a significant improvement in the FES-I ($P < 0.001$ and $P < 0.05$, respectively).

### 4.4. The Effect of a Selective Corrective Exercise on BBS in EGBP and EGNBP Compared to Control Group

A selective corrective exercise in both EGBP and EGNBP (Table 2) showed a significant improvement in BBS ($P < 0.001$ and $P < 0.05$, respectively).

### 4.5. The Effect of a Selective Corrective Exercise on the TUG in the EGBP and EGNBP Compared to Control Group

A selective corrective exercise on both EGBP and EGNBP (Table 2) showed a significant improvement in TUG ($P < 0.001$ and $P <0.05$, respectively).



**Table 1.** Participants' Demographic Data[a]

| Variable | Cont (n = 15) | EGBP (n = 15) | EGNBP (n = 14) | P Value [b] |
|---|---|---|---|---|
| **Age, y** | 57.22 ± 6.87 | 59.13 ± 8.37 | 58.77 ± 8.06 | .786 |
| **Gender** | | | | .870 |
| Male | 11 | 10 | 9 | |
| Female | 4 | 5 | 5 | |
| **Height, cm** | 163 ± 7.9 | 164.8 ± 8.8 | 162 ± 7.5 | .647 |
| **Weight, kg** | 71.24 ± 11.45 | 68.20 ± 10.59 | 69.89 ± 7.64 | .711 |
| **BMI, kg/m$^2$** | 26.18 ± 4.3 | 24.86 ± 2.6 | 25.52 ± 1.4 | .503 |
| **MMSE (range, 0 to 30)** | 26.4 ± 0.9 | 27.0 ± 1.0 | 26.7 ± 1.1 | .375 |
| **H and Y score (range, 1 to 5)** | 2.6 ± 0.5 | 2.53 ± 0.5 | 2.57 ± 0.5 | .938 |
| **DD, y** | 4.9 ± 1.8 | 4.9 ± 1.9 | 5.2 ± 2.0 | .847 |
| **NOF** | 1.2 ± 0.8 | 1.3 ± 0.8 | 1.2 ± 1.0 | .957 |
| **FES-I** | 41.4 ± 7.6 | 42 ± 6.4 | 43.2 ± 5.6 | .772 |
| **BBS** | 38.00 ± 4.94 | 38.73 ± 5.02 | 40.36 ± 6.77 | .520 |
| **TUG** | 13.26 ± 2.88 | 13.58 ± 2.58 | 14.23 ± 2.23 | .593 |

Abbreviations: BBS, Berg balance scale; BMI, body mass index; DD, disease duration; EGBP, exercise group with balance pad; EGNBP, exercise group with no balance pad; FES-I, falls efficacy scale- international; H&Y, Hahn & Yard; MMSE, mini-mental state examination; NOF, number of falling; TUG, timed up and go.
[a]Data are presented as mean ± SD.
[b]Based on ANOVA test.

**Table 2.** Differences Between the Groups (Control vs. EGBP / EGNBP) for the Secondary Outcome Measures Related to Number of Falling, Falls Efficacy Scale-International, Berg Balance Scale and Timed Up and Go[a]

| | Pre-test | Post-test (> 10 Weeks) | P Value [b] |
|---|---|---|---|
| **NOF** | | | |
| EGBP | 1.3 ± 0.8 | 0.2 ± 0.4 | .000 [c] |
| EGNBP | 1.2 ± 1.0 | 0.8 ± 0.7 | .225 |
| Cont | 1.2 ± 0.8 | 1.5 ± 1.0 | .487 |
| **FES-I** | | | |
| EGBP | 42 ± 6.4 | 26.8 ± 6.4 | .000 [c] |
| EGNBP | 43.2 ± 5.6 | 39.8 ± 3.9 | .031 [b] |
| Cont | 41.4 ± 7.6 | 42.7 ± 6.3 | .165 |
| **BBS** | | | |
| EGBP | 38.73 ± 5.02 | 46.20 ± 3.50 | .000 [c] |
| EGNBP | 40.36 ± 6.77 | 44.29 ± 4.14 | .047 [b] |
| Cont | 38.00 ± 4.94 | 38.20 ± 4.60 | .582 |
| **TUG** | | | |
| EGBP | 13.58 ± 2.58 | 11.92 ± 2.70 | .000 [c] |
| EGNBP | 14.23 ± 2.23 | 12.97 ± 2.17 | .012 [b] |
| Cont | 13.26 ± 2.88 | 13.34 ± 2.83 | .669 |

Abbreviations: BBS, Berg balance scale; Cont, control; EGBP, exercise group with balance pad; EGNBP, exercise group with no balance pad; FES-I, fall efficacy scale; NOF, number of falling; TUG, timed up and go.
[a]Data are presented as mean ± SD.
[b]Based on paired t-Test; $P < 0.05$.
[c]Based on paired t-Test; $P < 0.001$.



## 5. Discussion

Our study on idiopathic PP revealed that administrating a selective corrective exercise on a balance pad in EGBP group showed a significant difference in NOF, while without a balance pad in EGNBP group showed no significant difference. In addition, administrating the same exercise on both EGBP and EGNBP groups showed a significant improvement in FES-I, BBS and TUG.

Alzheimer's disease and PD are primary and secondary causes of neurodegeneration worldwide (33). Fall-related injuries are the cause of disability (70 - 87%) (34, 35)and higher rates of fractures in PD surviving for decades after PD onset (36).

The core medical management of PD is drug therapy to enhance decreased dopamine secretion. Anti-PD drugs are routinely used in the first stages of PD; their use in advance stages of the disease has no beneficial effect (37). Nevertheless, even with administration of best selective drugs, PP has repeated falls with destructive outcomes. Reportedly more than 68% of PP have a history of falling and up to 46% of people with PD disease would experience frequent falls annually (6, 22), which is two times more than normal individuals (6). Consistent with this finding, a one-year length study reported a yearly 27% falling rate among PP.

In addition, as reported by most PD researchers, falling etiology is multifactorial. Independent factors involved in higher falling risk are chronic nature of PD, having a sedentary lifestyle, multiple locomotor disorders, abnormal posture, freezing of gait, frontal impairment, impaired balance and reduced knee extensor strength (2, 12). Furthermore, osteoporosis and osteopenia are very common findings in patients with PD. Multiple mechanisms are involved in the occurrence of osteoporosis in PP including sedentary life, endocrine (i.e., lower vitamin D level), malnutrition and iatrogenic reasons, female sex, stages III and IV of Hoehn and Yahr criteria (24), aging and lower BMI (38). As PD usually occurs late in life, postural instability and unsteady gait disorders usually contribute to fall-related fractures.

Considering significance of fall-related injuries and fractures among this group, there is an urgent need to identify and use effective exercise interventions to reduce falls and related injuries in patients with PD. To date, only few clinical studies investigated corrective exercise interventions to reduce falls in patients with PD. In our study, we showed that administrating a selective corrective exercise in EGBP resulted in a significant difference in NOF between pre-test and post-test, while administrating the same exercise in EGNBP led to no significant difference between pre-test and post-test and only caused a 33.3% decrease in falling rate.

Reviewing the literature in senile group demonstrated the benefits and preventive role of exercise interventions on balance and lower extremity muscle strength in falling (14, 39). Moreover, a significant correlation between lower extremity muscle strength in PD and physical parameters has been reported (40, 41), which emphasizes the effect of exercise as an appropriate intervention in this group.

Reportedly posture instability is the main characteristic of late PD (2), which causes falling (42). It is well established that impaired balance is the probable psychological outcome of FOF. FOF is considered as immediate outcome preceding falls, which can result in severe immobility (6).

A series of studies (12, 17, 43-46) using some specific tools such as Berg Balance Scale, Functional reach test and Sensory Orientation Test (SOT) indicated balance as an outcome of PD and reported a significant improvement in balance. Nevertheless, Toole et al. (46) noticed an encouraging improvement on SOT, but not on the Berg Balance Scale. Cakit et al. (47) and Hackney et al. (48) showed an improvement in BBS in incremental speed-dependent treadmill training and progressive Tango lessons, respectively.

Caglar et al. using a home-based exercise (49) and Tamir et al. using a physiotherapy technique plus imagery (50) found the same findings and reported the efficient role of corrective exercise on TUG.

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## Footnote

**Authors' Contribution:**Hassan Daneshmandi, supervised the project. Noureddin Karimi and Amir-Hossein Barati, provided the advisory supervision. Parisa Sedaghati, performed the project, statistical analysis and prepared the first draft.

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