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Research article

Effects of proprioceptive neuromuscular facilitation on components of functional physical activity in patients with Parkinson's disease

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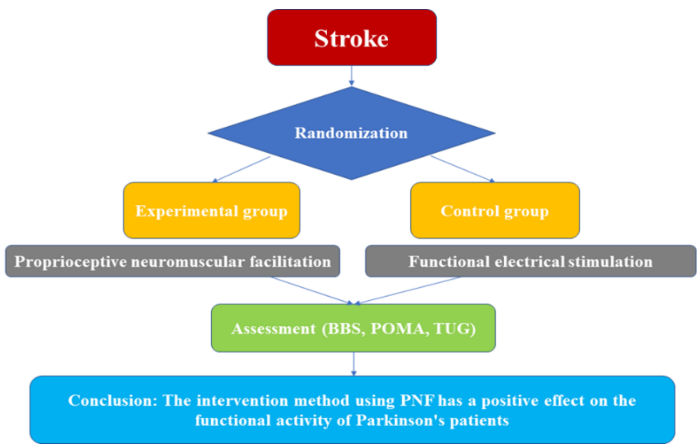
ABSTRACT

The purpose of this study was to investigate the effect of proprioceptive neuromuscular facilitation on the balance and gait required for functional activities in patients with Parkinson's disease. 16 patients were randomly assigned to an experimental group receiving Proprioceptive neuromuscular facilitation (PNF) and a control group receiving functional electrical stimulation. BBS, POMA, and TUG were used before and after intervention to evaluate balance and walking ability required for functional activities of patients. In the study results, all groups showed a significant increase in intra-group evaluation using BBS, POMA, and TUG, and in the analysis to investigate the difference in treatment effect between groups, there was a significant difference in POMA and TUG in the experimental group compared to the control group. In conclusion, the intervention method using PNF has a positive effect on the functional activity of Parkinson's patients.



Keywords: Parkinson's disease, PNF, Balance, Gait.

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INTRODUCTION

Parkinson's disease (PD) is a common neurodegenerative disorder that affects millions of people worldwide. It is characterized by the progressive degeneration of dopaminergic neurons in the substantia nigra pars compacta of the midbrain, leading to a deficiency of dopamine in the striatum. This dopamine deficiency is responsible for the motor symptoms of PD, including tremors, rigidity, bradykinesia, and postural instability [1]. The exact mechanism of Parkinson's disease is not fully understood, but it is believed to involve a complex interplay of genetic and environmental factors, as well as oxidative stress and inflammation [2].

Tremors are one of the most recognizable symptoms of PD and are typically characterized by a rhythmic shaking or trembling of the hands, arms, legs, jaw, and face. Tremors in PD are typically more prominent at rest and are often relieved by movement [3]. Rigidity is another common motor symptom of PD and is characterized by stiffness and resistance to movement in the muscles of the limbs and trunk. Rigidity can be either "cogwheel" rigidity, in which there is a jerky resistance to movement, or "lead pipe" rigidity, in which there is a continuous resistance to movement [4]. Bradykinesia, or slowness of movement, is a core motor symptom of PD and is often the first symptom to appear. It is characterized by a difficulty in initiating and executing voluntary movements, as well as a reduction in the amplitude and velocity of movements [5]. Postural instability, or difficulty maintaining balance and posture, is a common motor symptom of PD that typically appears in later stages of the disease. It is characterized by a tendency to fall backwards, as well as a stooped posture and shuffling gait [6].

PD is a neurodegenerative disorder that not only affects motor function but also cognitive function. Cognitive impairment is a common non-motor symptom of PD and can have a significant impact on a patient's quality of life. There are several types of cognitive impairment (executive dysfunction, attention and working memory impairment, visuospatial impairment, language impairment, memory impairment) that can occur in PD, each with its own specific characteristics [7]. Executive dysfunction is the most common type of cognitive impairment in PD and is characterized by difficulties in planning, decision-making, and multitasking. Patients with executive dysfunction may have difficulty initiating and completing tasks, as well as difficulty adapting to changing situations. This can lead to difficulties with activities of daily living and may impact a patient's ability to work or maintain social relationships [8].

Attention and working memory impairment are also common in PD and are characterized by difficulties in sustaining attention, focusing, and filtering out distractions. Patients with attention and working memory impairment may have difficulty remembering and processing new information and may experience frequent lapses in concentration [9]. Visuospatial impairment is characterized by difficulties in processing and interpreting visual information. Patients with visuospatial impairment may have difficulty navigating through their environment, judging distances, and recognizing objects and faces. This can lead to difficulties with driving, reading, and other visual tasks [10]. Language impairment is less common in PD but can occur in some patients. It is characterized by difficulties in word finding, comprehension, and expressive language. Patients with language impairment may have difficulty following conversations, expressing their thoughts clearly, and may have a reduced vocabulary [11]. Memory impairment is less common in PD than in other neurodegenerative disorders such as Alzheimer's disease, but can occur in some patients. It is characterized by difficulties in learning and recalling new information, as well as retrieving previously learned information. Patients with memory impairment may have difficulty remembering appointments, names, and other details, and may experience frequent forgetfulness [12].

Currently, many methods are being applied to treat physical and cognitive disorders caused by PD in clinical practice. Exercise therapy, drug therapy, and surgery are common methods for treating physical disorders [1,2], with proprioceptive neuromuscular facilitation being a representative exercise therapy. Proprioceptive neuromuscular facilitation (PNF) is a type of exercise therapy that is used to improve muscle strength, flexibility, and coordination [13,14]. PNF is based on the principles of proprioception, which refers to the body's ability to sense its own position and movement in space, and neuromuscular facilitation, which refers to the body's ability to activate and coordinate muscles for movement [15]. The principles of PNF are based on the idea that the body's muscles are interconnected and can be activated and coordinated in a specific pattern to improve movement and function. PNF exercises involve a combination of stretching and resistance exercises, which are performed in a specific pattern that is designed to activate and coordinate the muscles of the body in a specific way [16].

In a systematic review of the effectiveness of PNF treatment for individuals with PD, a comprehensive search was conducted across multiple databases, resulting in the selection of six articles for analysis [14]. Focusing on three articles with the same outcomes (walking speed, stride length, and cadence) the meta-analysis revealed that PNF was similar or superior to other therapies in terms of improving gait speed. However, this study suggests that the efficacy of PNF for PD needs further investigation due to the lack of a sufficient number of high-quality, well-designed randomized controlled trials. Therefore, in this study, participants were randomly assigned to either an experimental group, which received PNF treatment, or a control group, which received functional electrical stimulation treatment. The aim was to investigate the impact of these interventions on balance maintenance and walking ability in patients with PD.

MATERIALS AND METHODS

Subjects

The subjects of this study were 16 patients diagnosed with PD by a medicine specialist. Prior to participation in the experiment, participants were asked to choose A or B cards, and subjects who selected card A were assigned to the experimental group receiving intervention using PNF, and subjects who selected card B were assigned to the control group receiving functional electrical stimulation therapy. The experimental group received training using upper and lower extremity patterns of PNF for 30 minutes after general physical therapy, and the control group received functional electrical stimulation treatment for upper and lower extremities for 30 minutes after general physical therapy. The intervention of the experimental group and the control group was performed by one physical therapist who had more than 10 years of clinical experience and completed an international course in PNF.

Before participating in the study, all subjects received a detailed explanation of the purpose, process, potential side effects, and compensation related to the experiment. They were also educated about their right to withdraw from the study at any time. After receiving this information, participants provided their informed consent by signing a consent form. All procedures in this study were conducted in accordance with the Declaration of Helsinki.

Intervention methods

Proprioceptive neuromuscular facilitation

In this study, the experimental group underwent a PNF intervention involving both lowering and lifting patterns for the upper limbs and specific patterns for the lower limbs. For the upper limbs, the lowering pattern began with participants in the supine position, with both feet fixed to the wall. The leading left shoulder joint was placed in flexion-adduction-external rotation, the scapula in anterior elevation, the elbow joint in extension-supination, and the wrist in flexion-radial deviation. Resistance was applied to the left shoulder joint in the direction of extension-abduction-internal rotation, generating movement. At the end of the range of motion, the shoulder joint was positioned in extension-abduction-internal rotation, the scapula in posterior descent, the elbow joint in extension-pronation, and the wrist in extension-ulnar deviation. To enhance trunk stability, the isotonic combination technique was repeated five times, followed by a five-second approximation with resistance applied in the opposite direction to the patient's pressing force.

The lifting pattern was initiated in the supine position, with both feet fully touching the wall, starting with the left side and then the right side. The leading left shoulder joint began in extension-adduction-internal rotation, with the scapula descending anteriorly, the elbow joint in extension-pronation, and the wrist in flexion-ulnar deviation. In this position, resistance was applied to the left shoulder joint in the direction of flexion-abduction-external rotation, generating movement. At the end of the range of motion, the left shoulder joint was positioned in flexion-abduction-external rotation, the scapula in posterior elevation, the elbow joint in extension-supination, and the wrist in extension-radial deviation. To enhance trunk stability at the end of the pattern, the isotonic combination technique was repeated five times, followed by a five-second approximation with resistance applied in the opposite direction to the patient's pressing force.

For the lower limbs, PNF was applied starting with knee joint extension, hip extension-abduction-internal rotation, and plantar flexion-valgus for the ankle joint. Next, the pattern transitioned to knee flexion, hip flexion-adduction-external rotation, and ankle joint dorsiflexion, and then to toe extension posture, before moving to the opposite pattern and returning to the original starting position. In hip extension-adduction-external rotation and knee extension, the ankle began in plantar flexion-varus and toe flexion. In hip flexion-abduction-internal rotation and knee flexion, the ankle was positioned in dorsiflexion-valgus and toe extension before returning to the starting position. The pattern was performed in the supine position. The PNF intervention aimed to improve participants' functional mobility, balance, and overall motor control by utilizing specific movement patterns and resistance techniques. The combination of upper and lower limb PNF patterns targeted both gross and fine motor skills, as well as trunk stability, ultimately contributing to enhanced performance in daily activities and reduced fall risk.

Functional electrical stimulation

In this study, a functional electrical stimulation (MyoPro, Myomo Inc., USA) device was used to apply FES to the upper limbs. The attachment sites were 4-5 cm away from the lateral epicondyle, 4-5 cm away from the medial epicondyle, and on the wrist tendons of the flexor and extensor muscles. The stimulation method included a 2-second ramp-up time to reach maximum intensity, a 6-second hold time, a 2-second ramp-down time for the stimulus to disappear from the maximum intensity, and a 6-second rest period. The frequency was set at 35 Hz, and the output ranged from 10-20 mA. The alternating output was applied to the flexor and extensor muscles during training.

In this study, FES therapy for the lower limbs was conducted using the FES equipment (Walking Man II, Cyber Medic, Korea) device, with a 5-minute exercise stimulation mode and a 10-minute gait stimulation mode. To determine the FES stimulation site and position in advance, patients were seated in a chair with a backrest. The self-adhesive surface electrodes were attached to the quadriceps and tibialis anterior muscles, ensuring knee extension and ankle dorsiflexion functional movements during FES stimulation. The electrodes used were 2-channel single adhesive electrodes; one channel was attached to the quadriceps, and the other channel was attached to the tibialis anterior. The stimulation conditions were set to a rectangular biphasic waveform with a pulse width of 400 μs and a fixed stimulation frequency of 40 Hz. Both the rise and fall times for the stimulation were set to 0.3 seconds. The stimulation intensity was adjusted according to the patient's functional recovery level, inducing accurate lower limb movements through therapist observation. The quadriceps and tibialis anterior contractions were set at a level that the patient could tolerate.

Assessment methods

In this study, the BBS, POMA, and TUG was employed to assess the balance, gait, and fall risk of participants before and after the intervention, in order to determine the effectiveness of the proposed treatment method.

Berg balance scale

The Berg balance scale (BBS) is a widely utilized assessment tool that was incorporated into the research methodology of this thesis to evaluate the balance and fall risk of participants. This scale is a reliable and valid instrument for measuring functional balance in both clinical and research settings. The scale consists of 14 tasks, each representing a different aspect of balance control. These tasks include sit-to-stand, standing unsupported, sitting unsupported, standing to sitting, transfers, standing with eyes closed, standing with feet together, reaching forward with an outstretched arm, retrieving an object from the floor, turning to look behind, turning 360 degrees, placing alternate foot on a stool, standing on one foot, and tandem standing.

Each of these tasks is scored on a five-point ordinal scale, ranging from 0 (unable to perform the task) to 4 (independent performance without difficulty). The maximum total score for the BBS is 56, indicating excellent balance, while a score below 45 suggests an increased risk of falls. During the assessment, participants were instructed to wear comfortable clothing and supportive footwear.

Tinetti performance-oriented mobility assessment

The Tinetti Performance-Oriented Mobility Assessment (POMA), also known as the Tinetti test, was incorporated into the research methodology of this thesis as a comprehensive tool to evaluate participants' gait and balance. The POMA consists of two subscales: the Balance subscale, which includes 9 items, and the Gait subscale, which includes 7 items. Each item is scored on a three-point ordinal scale, ranging from 0 (most impaired) to 2 (normal performance). The Balance subscale evaluates sitting balance, arising, immediate standing balance, standing balance, nudged standing balance, eyes closed standing balance, turning 360 degrees, and sitting down. The Gait subscale assesses initiation of gait, step length and height, step symmetry, step continuity, path deviation, trunk stability, and walking stance. The maximum total score for the POMA is 28, with a higher score indicating better performance. A score below 19 suggests a high risk of falls.

Timed up and go test

The timed up and go (TUG) test used in this study is a practical and simple tool to assess participants' mobility, functional ability, and fall risk. The TUG test is widely used in clinical and research settings to evaluate balance and functional mobility in older adults and various patient populations. The test requires participants to stand up from a seated position in a chair, walk 3 meters, turn around, walk back to the chair, and sit down again. The time taken to complete the task is recorded in seconds, with a shorter time indicating better functional mobility. A time greater than 13.5 seconds is generally considered to be indicative of an increased risk of falls in older adults. Each participant performed the TUG test three times, with sufficient rest periods between trials to minimize fatigue. The average time of the three trials was calculated and used for data analysis.

A trained assessor, blinded to the group allocation, administered the BBS, POMA, and TUG in a quiet and well-lit room. The assessor provided standardized instructions and demonstrations of each task, ensuring that participants fully understood the requirements before commencing. To minimize fatigue and ensure safety, participants were given sufficient rest periods between tasks, and the assessor remained nearby to provide assistance if needed.

Data analysis

In this study, the general characteristics of the subjects and the measurement values of the assessment tools were statistically analyzed using SPSS Windows version 18.0. Descriptive statistics were used to display the measurement values as means and standard deviations, and independent t-tests were conducted to evaluate the homogeneity between groups. Paired t-tests were used for within-group analyses of pre- and post-assessments, and independent t-tests were conducted to determine the differences in treatment effects between groups. The significance level was set at $p<0.05$.

RESULTS AND DISCUSSION

Results of study

Table 1 presents the results of the tests for homogeneity of general characteristics of subjects and pre-evaluation items between the experimental group and the control group, the data is expressed as mean ± standard deviation (Table 1). The aim of these tests was to ensure that there were no significant differences between the two groups at baseline, which would allow for a fair comparison of the intervention's effects on the outcome measures.

Table 1. Test for the homogeneity of general characteristics of subjects and pre-evaluation items

	EX	CG	t	P
Age (year)	65.38±2.32	65.50±2.26	-0.109	0.915
Height (cm)	165.50±4.81	166.50±3.96	-0.454	0.657
Weight (kg)	61.63±2.82	62.25±3.37	-0.402	0.694
BBS (score)	41.13±2.23	41.25±2.31	-0.110	0.914
POMA (score)	23.63±1.92	24.75±1.48	-1.309	0.212
TUG (second)	13.00±1.06	13.88±1.35	-1.433	0.174

*Mean±SD: mean±standard deviation; EX: experimental group; CG: control group; BBS: Berg balance scale; POMA: Tinetti performance-oriented mobility assessment; TUG: timed up and go test; *p<0.05*

The age of participants in the experimental group was 65.38 ± 2.32 years, while in the control group, it was 65.50 ± 2.26 years. The height of participants in the experimental group was 165.50 ± 4.81 cm, and in the control group, it was 166.50 ± 3.96 cm. The weight of participants in the experimental group was 61.63 ± 2.82 kg, while in the control group, it was 62.25 ± 3.37 kg. The t-test revealed no significant difference between the two groups in terms of general characteristics.

Regarding the pre-evaluation items, the Berg balance scale scores for the experimental group were 41.13 ± 2.23, while for the control group, they were 41.25 ± 2.31. The Tinetti performance-oriented mobility assessment scores for the experimental group were 23.63 ± 1.92, and for the control group, they were 24.75 ± 1.48. Lastly, the timed up and go test results for the experimental group were 13.00 ± 1.06 seconds, and for the control group, they were 13.88 ± 1.35 seconds. No significant difference was observed between the groups in terms of BBS, POMA, and TUG test results.

The experimental group experienced a significant increase in BBS scores from 41.13±2.23 pre-test to 44.38±2.26 post-test (t=-

5.508, p=0.001*) (Table 2), while the control group also showed significant improvement from 41.25±2.31 pre-test to 43.88±2.64 post-test (t=-5.274, p=0.001*).

Table 2. Within-group comparative analysis of BBS, POMA, and TUG to evaluate balance ability

	Group	Pre-test	Post-test	t	P
BBS	EX	41.13±2.23	44.38±2.26	-5.508	0.001*
(score)	CG	41.25±2.31	43.88±2.64	-5.274	0.001*
POMA	EX	23.63±1.92	27.13±1.88	-6.548	0.000*
(score)	CG	24.75±1.48	26.88±1.88	-7.202	0.000*
TUG	EX	13.00±1.06	10.13±0.99	7.222	0.000*
(second)	CG	13.88±1.35	12.38±1.30	5.612	0.001*

*Mean±SD: mean±standard deviation; EX: experimental group; CG: control group; BBS: Berg balance scale; POMA: Tinetti performance-oriented mobility assessment; TUG: timed up and go test; *p<0.05*

Similarly, POMA scores improved significantly in both groups. The experimental group increased from 23.63±1.92 pre-test to 27.13±1.88 post-test (t=-6.548, p=0.000*), while the control group improved from 24.75±1.48 pre-test to 26.88±1.88 post-test (t=-7.202, p=0.000*). Finally, the TUG test results demonstrated significant improvements in balance for both groups as well. The experimental group showed a decrease in time from 13.00±1.06 seconds pre-test to 10.13±0.99 seconds post-test (t=7.222, p=0.000*), indicating better balance and mobility. Similarly, the control group experienced a significant reduction in time from 13.88±1.35 seconds pre-test to 12.38±1.30 seconds post-test (t=5.612, p=0.001*). In conclusion, the results from this study indicate that both the experimental and control groups experienced significant improvements in balance ability, mobility, and reducing fall risk, as assessed by the BBS, POMA, and TUG tests.

Table 3 presents a comparative analysis between the experimental and control groups to assess the improvement in functional ability after the intervention (Table 3).

Table 3. Comparative analysis between groups to compare improvement in balance ability

Group	EX	CG	t	p
BBS (score)	-3.25±1.66	-2.63±1.40	-0.810	0.432
POMA (score)	-3.50±1.51	-2.13±0.83	-2.252	0.041*
TUG (second)	2.88±1.12	1.50±0.75	2.868	0.012*

*Mean±SD: mean±standard deviation; EX: experimental group; CG: control group; BBS: Berg balance scale; POMA: Tinetti performance-oriented mobility assessment; TUG: timed up and go test; *p<0.05*

For the BBS scores, the experimental group showed a mean improvement of -3.25±1.66, while the control group demonstrated a mean improvement of -2.63±1.40. The between-group difference was not statistically significant (t=-0.810, p=0.432), indicating that the intervention did not result in a significant difference in BBS score improvement between the two groups. In contrast, the POMA scores showed a significant between-group difference. The experimental group had a mean improvement of -3.50±1.51, while the control group had a mean improvement of -2.13±0.83. The difference in improvement was statistically significant (t=-2.252, p=0.041*), suggesting that the intervention was more effective for the experimental group in terms of POMA score improvement. Similarly, the TUG test results also revealed a significant between-group difference. The experimental group had a mean improvement of 2.88±1.12 seconds, while the control group had a mean improvement of 1.50±0.75 seconds in the TUG test. The difference in improvement was statistically significant (t=2.868, p=0.012*), indicating that the intervention was more effective for the experimental group in terms of TUG test improvement. These findings suggest that the intervention was more effective for the experimental group in enhancing balance and mobility, as assessed by the POMA and TUG tests.

DISCUSSION

Postural instability is a common and debilitating symptom of Parkinson's disease. It refers to the difficulty in maintaining balance and can result in falls, which can lead to serious injury. Postural instability in PD is caused by a combination of factors, including the loss of muscle stiffness, and impaired reflexes. Muscle stiffness is another factor that contributes to postural instability in Parkinson's disease [17]. Stiff muscles make it difficult to adjust to changes in the environment, such as uneven surfaces or unexpected obstacles. This can lead to a loss of balance and falls [18]. Finally, impaired reflexes can also contribute to postural instability in Parkinson's disease. Reflexes play a crucial role in maintaining balance by allowing the body to respond quickly to changes in the environment. In Parkinson's disease, reflexes may be impaired, making it difficult to maintain balance and respond to changes in the environment [19].

Gait disorders are another common symptom of PD. Gait disorders refer to abnormalities in walking patterns and can include a shuffling gait, short steps, difficulty with turning, and a reduced arm swing. Muscle stiffness in Parkinson's disease can affect the normal walking pattern and result in a shuffling gait. The reduced arm swing is also related to muscle stiffness and can affect balance control. Impaired reflexes can make it difficult to adjust to changes in the environment, such as turning or stopping, which can affect the walking pattern [20]. Treatment for gait disorders in Parkinson's disease may include medication to increase dopamine levels, physical therapy to improve muscle strength and flexibility, and gait training to improve walking patterns. [2]. In addition, assistive devices such as canes or walkers may be used to provide additional support and improve balance. It is important to address gait disorders in Parkinson's disease, as they can significantly impact a patient's quality of life and increase the risk of falls and injury [21].

Postural instability and gait disorders in Parkinson's disease can have a significant impact on a patient's ability to perform daily activities. The loss of balance and abnormal walking patterns can limit mobility and independence, leading to a reduction in quality of life. Activities such as walking, getting up from a chair, and climbing stairs may become difficult or impossible for patients with postural instability and gait disorders [18,20]. In addition, postural instability and gait disorders can affect social and leisure activities. Patients may be hesitant to participate in activities that require mobility, such as going for walks or attending social events. This can lead to social isolation and a reduced quality of life. It is important to address postural instability and gait disorders in Parkinson's disease to improve the patient's ability to perform daily activities and maintain independence [22].

Currently, there is ongoing research in clinical settings to explore effective treatment methods for postural instability and decreased locomotion in Parkinson's disease [23]. In previous study, researchers investigated whether targeted rehabilitation focused on improving balance in Parkinson's disease patients could also improve locomotion [24]. In this study, two balance-training protocols were tested in Parkinson's patients, and both improved balance and gait. The four-week program focused on challenging balance tasks without gait training and resulted in significant gait improvements in mildly to moderately affected patients.

In a systematic review study that investigated the effects of robot-assisted gait training on postural instability in patients with Parkinson's disease, postural instability was found to be a highly disabling symptom that affects patients' quality of life [25]. The study found a high level of evidence for the positive effects of robot-assisted gait training on balance and freezing of gait in Parkinson's disease patients. However, it was pointed out that the treatment method using a robot is expensive and requires a lot of time to apply the robot to the body. In another systematic review study that investigated the effects of virtual reality (VR) rehabilitation training on gait and balance in patients with Parkinson's disease [26]. VR rehabilitation training demonstrated significant effects on the improvement of quality of life, level of confidence, and neuropsychiatric symptoms, while it may have similar effects on global motor function, activities of daily living, and cognitive function. However, this review suggests that a more rigorous design of a large-sample, multicenter randomized controlled trial is needed to provide a stronger evidence-based basis for testing potential benefits.

In a clinical study investigating the effects of rehabilitation therapy using proprioceptive neuromuscular facilitation on patients with Parkinson's disease [27]. Based on the results, individual therapeutic rehabilitation using PNF techniques was planned to improve movement and approach biomechanical standards. After three weeks of therapy, improvements in gait rhythm and approaching standards of frequency and speed were observed. Another clinical study aimed to investigate the effects of trunk exercise using PNF combined with treadmill training on balance and walking ability in Parkinson's disease patients [28]. Both groups showed improvement, but the experimental group had significantly greater improvements in all measured outcomes, indicating that trunk exercise using PNF plus treadmill training can be more effective than conventional training plus treadmill training for improving balance and walking ability in Parkinson's disease patients.

In this study, in order to overcome the problem presented as a limitation based on previous studies, the effect of the PNF method on the functional activity of Parkinson's patients was investigated by dividing the group into an experimental group and a control group using a random distribution method. The results of this study showed a statistically significant difference in all evaluation items between the experimental group, which received PNF, and the control group, which received functional electrical stimulation, in the pre- and post-evaluation comparison. This confirms the therapeutic effect of both PNF and FES, which are currently used in clinical practice. The comparison of treatment effects revealed a statistically significant improvement in the experimental group, as evidenced by the effect size on POMA and TUG evaluations, as compared to the control group. These results suggest that the application of PNF during training stimulated motor learning and motor control in the nervous system through continuous feedback, resulting in improvements in balance and walking ability for patients with Parkinson's disease. The increase in muscle strength, endurance, and coordination using the resistance transmitted through the therapist during PNF application may have contributed to the correct reeducation of the necessary muscles. These findings highlight the potential of PNF as a therapeutic approach for improving functional activity in patients with Parkinson's disease.

The study has some limitations, including a small sample size and a relatively short intervention period, despite the use of a random allocation method. Further studies could explore the optimal duration, frequency, and intensity of PNF training for patients with PD. It may also be valuable to investigate the effects of PNF in combination with other therapies or interventions, such as medication or deep brain stimulation. Furthermore, research could examine the underlying mechanisms of how PNF improves balance and walking ability in patients with PD, such as changes in neural plasticity or muscle activation patterns. Finally, it may be important to investigate the feasibility and effectiveness of home-based PNF training programs for patients with PD to increase accessibility and convenience of this therapy.

CONCLUSION

Since Parkinson's disease is a disease that causes various disorders through complex mechanisms, effective treatment intervention methods must be included in the process of constructing a rehabilitation program for the treatment of PD. This study investigated the effects of training using PNF, which is applied in clinical neurorehabilitation, on balance and gait required for functional activities in Parkinson's patients. In the results of the study, the experimental group to which PNF was applied showed improvements in balance and walking ability compared to the control group. Based on these results, the rehabilitation program for Parkinson's patients should include training using PNF.

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Conflict of interest:

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