

“EFFECTIVENESS OF FRENKEL’S EXERCISES VERSUS LUMBAR STABILIZATION EXERCISES USING THE PNF TECHNIQUE IN IMPROVING BALANCE IN STROKE PATIENTS”

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ABSTRACT

BACKGROUND: Stroke is a leading cause of long-term disability and often results in impaired balance and reduced functional independence. Trunk instability and poor postural control are major contributors to balance deficits in stroke patients. Improving trunk stability through specific rehabilitation techniques may enhance balance and functional outcomes.

OBJECTIVE: To find out the effectiveness of Frenkel’s exercises and lumbar stabilization exercises using PNF techniques in improving balance among post-stroke patients.

METHODS: An experimental study was conducted on 30 post-stroke patients, who were randomly divided into two groups, each comprising 15 subjects. Group I received Frenkel’s exercises, and Group II received lumbar stabilization exercises combined with PNF techniques. Balance was assessed using the Berg Balance Scale (BBS) before and after the intervention. Outcome measures included the Berg Balance Scale, which was used to assess balance.

DURATION: The total intervention period was six weeks. Group I received Frenkel’s exercises for 45 minutes per session, three times per week, while Group II performed lumbar stabilization exercises with the same frequency and session duration over the six-week period.

RESULTS: Both groups showed significant improvement in balance following the intervention. However, Group II demonstrated greater improvement compared to Group I. Indicating superior effectiveness of lumbar stabilization exercises with PNF techniques.

CONCLUSION: The study concludes that lumbar stabilization exercises combined with PNF techniques are more effective than Frenkel’s exercises in improving balance among post-stroke patients. These exercises can be recommended as an effective rehabilitation approach to enhance balance and functional stability in stroke patients.

KEYWORDS: Stroke, Balance, Lumbar Stabilization, PNF , Frenkel’s Exercises, Berg Balance Scale, Trunk Stability.

INTRODUCTION

According to the World Health Organization (WHO), stroke is defined as a rapidly developing clinical condition characterized by focal or global disturbances of cerebral function lasting more than 24 hours or leading to death, with no apparent cause other than vascular origin. Stroke occurs when the blood supply to the brain is interrupted or reduced, resulting in inadequate oxygen delivery and subsequent neuronal cell death. This interruption is most commonly caused by thrombus formation, embolism, or hemorrhage.

Stroke remains one of the three leading causes of mortality worldwide, alongside malignant tumors and heart disease. ^{[1] [2]}

Stroke survivors frequently experience functional impairments and activity limitations that significantly affect their ability to perform roles within the family, workplace, and community. ^{[1] [2]} Among these impairments, mobility limitation is one of the most prevalent consequences of stroke, often leading to increased physical inactivity, sedentary behaviour, and long-term disability. Despite its high prevalence, stroke is both a preventable and treatable condition. Adoption of a healthy lifestyle and effective management of modifiable risk factors play a crucial role in stroke prevention. Common symptoms of stroke include confusion, difficulty in speaking and understanding speech, severe headache accompanied by altered consciousness or vomiting, numbness or weakness of the face and limbs (particularly on one side of the body), visual disturbances, dizziness, loss of balance, and impaired coordination. The long-term consequences of stroke largely depend on the speed of diagnosis and initiation of appropriate treatment. ^{[1] [2] [3]}

Balance rehabilitation is a primary goal in stroke recovery, as it is closely associated with independent mobility and functional ambulation. Balance is achieved through the complex interaction of multiple systems, including the visual, vestibular, proprioceptive, musculoskeletal, and cognitive systems. Effective balance maintenance is essential for safe and independent performance of daily activities such as standing, walking, and transitional movements. Balance impairments are common after stroke and significantly influence mobility and activities of daily living. Consequently, balance training is one of the most frequently employed physiotherapeutic interventions in inpatient rehabilitation settings, although it presents challenges in ensuring both safety and therapeutic effectiveness. ^{[4] [5]}

Balance is defined as the ability to maintain an upright posture, and stroke patients with impaired balance control are at a high risk of falls. Falls in stroke survivors can lead to serious complications, emphasizing the importance of appropriate therapeutic interventions aimed at improving balance and preventing fall-related injuries. Balance control involves the integration and coordination of sensory input and motor output to the head, eyes, trunk, and limb muscles. ^{[4] [6]}

Frenkel's exercises, developed by Professor Heinrich Sebastian Frenkel, consist of a structured program of slow, repetitive movements that progressively increase in difficulty. These exercises are designed to enhance coordination and balance by improving sensory feedback and proprioceptive control. Frenkel's exercises have been shown to be effective in improving sensory integration and balance recovery in subacute ischemic stroke patients with impaired proprioception and minimal lower limb motor weakness. The exercises are performed in supine, sitting, and standing positions, focusing on limb coordination and the integration of visual input with body movements. Trunk stability also plays a vital role in postural control and functional mobility. Adequate muscular strength and endurance of the trunk muscles are essential for maintaining posture and executing controlled movements during daily activities. Vertebral stabilization exercises emphasize precise activation of the transverse abdominis and deep trunk muscles, contributing to spinal stability and reduction of functional limitations. Lower trunk stabilization exercises in stroke patients have been shown to improve trunk stability, enhance postural control, and promote neuromuscular efficiency throughout the kinetic chain. ^{[5] [6] [7]} This proximal stability facilitates efficient limb movement, dynamic balance, and overall functional improvement during movement execution. Finally, this study is structured as a comparative experimental design aimed at evaluating and comparing the effectiveness of Frenkel's exercises and lumbar stabilization exercises using PNF techniques in improving balance among stroke patients.

NEED OF THE STUDY

India is a densely populated country where stroke has emerged as a relatively common neurological condition and a major contributor to morbidity and mortality. One of the primary goals of the rehabilitation process is to enable stroke survivors to achieve the highest possible level of functional independence within the limitations imposed by their impairments. Among the various post-stroke deficits, balance impairment is one of the most significant, as it directly affects mobility and the performance of activities of daily living. Consequently, improving balance is a crucial component of stroke rehabilitation. Many stroke survivors experience repeated episodes of falling due to impaired balance and postural control, which further increases the risk of injury and limits functional recovery. Previous studies have demonstrated the

effectiveness of Frenkel's exercises in improving balance, while other research has shown that lumbar stabilization exercises combined with Proprioceptive Neuromuscular Facilitation (PNF) techniques also play a significant role in enhancing balance and postural stability. However, there is limited comparative evidence evaluating the relative effectiveness of these two exercise protocols in stroke rehabilitation.

Therefore, the present study is undertaken to generate evidence on the effectiveness of Frenkel's exercises versus lumbar stabilization using the PNF technique in improving balance among stroke patients and to determine which intervention yields superior outcomes.

AIM OF THE STUDY

To determine the effectiveness of Frenkel's exercises versus lumbar stabilization using the Proprioceptive Neuromuscular Facilitation (PNF) technique in improving balance among stroke patients.

OBJECTIVE OF THE STUDY

To examine and compare the effectiveness of Frenkel's exercises and lumbar stabilization exercises using the Proprioceptive Neuromuscular Facilitation (PNF) technique on balance in post-stroke patients measured by the Berg Balance Scale (BBS).

METHODOLOGY

Study Design - A comparative research design was adopted for the present study.

Study period – The protocol was implemented for four weeks

Sample size – 30

A total of 30 subjects were selected and split into two equal groups using a random drawing method

Study setup - The data for the study were collected from the Inpatient Department of KKC College of Physiotherapy, Parameswara Mangalam, Tirupati District, Andhra Pradesh, India.

Population - The study population comprised unilateral stroke patients, including both ischemic and hemorrhagic stroke cases, diagnosed by a neurologist using neuroimaging procedures such as Computed Tomography (CT) scan or Magnetic Resonance Imaging (MRI).

INCLUSION CRITERIA

- Patients clinically diagnosed with unilateral ischemic or hemorrhagic stroke.
- Diagnosis confirmed by a neurologist using neuroimaging (CT scan or MRI).
- Both male and female participants.
- Age between 40 and 70 years.
- Berg Balance Scale (BBS) score >21.
- Patients with clear consciousness and stable vital signs.
- Patients are able to follow verbal commands and actively participate in the exercise program.
- Patients who are willing to participate and who have provided written informed consent.

EXCLUSION CRITERIA

- Presence of cognitive impairment or severe mental disorders.
- Patients are unable to perform Frenkel's exercises or lumbar stabilization exercises.
- Presence of cerebellar ataxia.
- Disorders of consciousness.
- Any other neurological or musculoskeletal condition affecting balance or mobility.

OUTCOME:

The Berg Balance Scale (BBS) was used to assess balance in stroke patients.

STUDY PROCEDURE

A total of 30 stroke patients who met the inclusion criteria were selected from the Inpatient Department of KKC College of Physiotherapy. Written informed consent was obtained from all participants before the commencement of the study. Baseline balance assessment was performed using the Berg Balance Scale (BBS). The participants were then randomly divided into two groups, with 15 subjects in each group.

Group 1 received Frenkel's exercises, while Group 2 received lumbar stabilization exercises using the Proprioceptive Neuromuscular Facilitation (PNF) technique. Both groups underwent their respective exercise programs under the supervision of a physiotherapist for the prescribed duration. After completion of the intervention period, balance was reassessed using the Berg Balance Scale and the pre- and post-intervention scores were compared to determine the effectiveness of the two exercise protocols.

ASSESSMENT OF THE BERG BALANCE SCALE (BBS) FOR GROUP A AND GROUP B

The Berg Balance Scale (BBS) was used to assess functional balance in both Group A and Group B. It is a 14-item scale designed to evaluate balance performance during various static and dynamic standing activities. Each item is scored on a scale of 0 to 4, with a maximum total score of 56, where higher scores indicate better balance. The assessment typically takes approximately 10–20 minutes to complete. The BBS is a reliable and valid outcome measure commonly used to assess balance in stroke patients.

Intervention for Group A (Frenkel's Exercises)

Frenkel's exercises were performed in sitting, standing, and stride-standing positions with emphasis on slow, controlled, and visually guided movements.

➤ **Sitting Position:**

1. Sliding the heel of one leg to a predetermined mark on the floor.
2. Alternately stretching and lifting each leg to place the heel or toe on a specified mark.
3. Transitioning from a strided sitting to standing and returning to sitting.
4. Sitting down with knees flexed and the trunk slightly bent forward.

➤ **Standing Position:**

5 Standing with controlled weight transfer from one foot to the other.

➤ **Stride Standing Position:**

6. Walking sideways and returning to the starting position.
7. Turning at a 90-degree angle.
8. Walking in a zigzag pattern.
9. Heel-to-toe walking.

INTERVENTION FOR GROUP B (LUMBAR STABILIZATION EXERCISES USING PNF TECHNIQUE)

Lumbar stabilization exercises focusing on trunk control and core stability were performed in supine, kneeling, and sitting positions.

Supine Position:

1. Pelvic bridging – 10 repetitions × 3 sets.
2. Unilateral bridging – 10 repetitions × 3 sets.

3. Alternate upper limb shoulder and elbow flexion with lower limb hip and knee flexion to 90°.
4. Superman pose – 3 sets of 10 seconds each.
5. Kneeling – 3 sets of 30 seconds.
6. Half kneeling – 3 sets of 30 seconds.
7. Trunk rotation – 10 repetitions × 3 sets.

Sitting Position:

8. High sitting – PNF splinter pattern – 10 repetitions × 3 sets.
9. Splinter pattern combined with stabilization technique.

STATISTICAL ANALYSIS

The collected data were entered and analyzed using Microsoft Excel 2007 and the Statistical Package for the Social Sciences (SPSS). The Berg Balance Scale (BBS) was used as the outcome measure to assess balance in stroke patients. Descriptive statistics such as mean and standard deviation were calculated, and the results were presented in the form of tables, charts, and graphs.

A paired *t*-test was used to compare the pre- and post-intervention scores within each group. An unpaired *t*-test was applied to compare the mean differences between Group A and Group B. The level of statistical significance was set at 5% ($p < 0.05$) for the present study.

RESULTS

TABLE 1: MEAN OF BERG BALANCE SCALE IN GROUP 1 AND GROUP 2

Descriptive statistics

Group 1 BBS	Paired t-test			
	Mean	SD	t Value	P value`
Pre Test	34.4	5.77	-12.43	<0.001
Post Test	38.13	5.77		
Group 2 BBS	Paired t-test			
	Mean	SD	t Value	P value`
Pre Test	35.07	5.42	-10.52	<0.001
Post Test	42.6	6.21		

Table 1 represents the descriptive statistics and paired t-test results for two groups assessing Berg Balance Scale (BBS) scores before and after an intervention. In Group 1, the mean BBS score increased from 34.4 ± 5.77 at pre-test to 38.13 ± 5.77 at post-test, with a paired t-test value of -12.43 and a p-value of <0.001, which is statistically significant. Similarly, Group 2 showed an increase in mean BBS scores from 35.07 ± 5.42 at pre-test to 42.6 ± 6.21 at post-test, with a t-value of -10.52 and a p-value of <0.001, also indicating a statistically significant improvement. Overall, both groups demonstrated significant improvements in balance following the intervention, with Group 2 showing a slightly larger increase in mean scores.

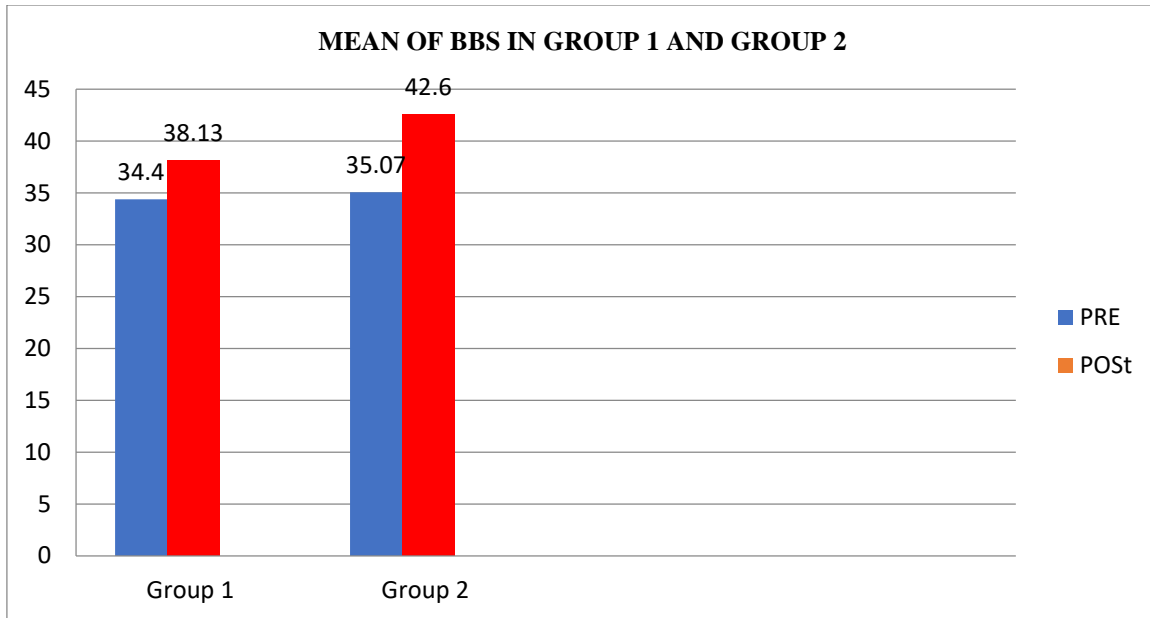


FIG 1: Mean of Berg Balance Scale in group 1 and group 2

TABLE 2: MEAN OF BERG BALANCE SCALE IN GROUP 1 AND GROUP 2

Descriptive statistics

	G R O U P 1 P O S T I V E	G R O U P 2 P O S T I V E	P – value
B B S	3 8 . 1 3 ± 5 . 7 7	4 2 . 6 0 ± 6 . 2 1	< 0.05

Table 2 summarizes the post-intervention comparison of Berg Balance Scale (BBS) scores between Group 1 and Group 2. Group 1 had a mean post-test BBS score of 38.13 ± 5.77 , while Group 2 showed a higher mean of 42.60 ± 6.21 . The difference between the two groups was statistically significant, with a p-value of <0.05 , indicating that Group 2 demonstrated a greater improvement in balance compared to Group 1 following the intervention.

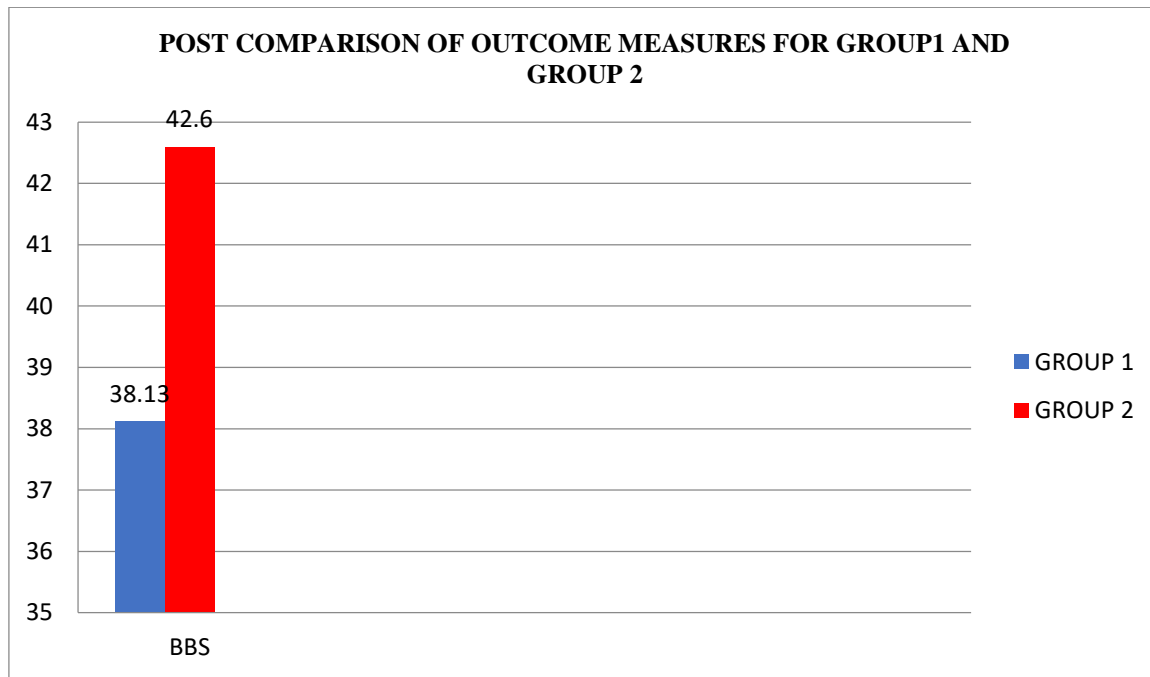


FIG 2: Post comparison of outcome measures for group1 and group 2

DISCUSSION

Stroke is one of the leading causes of long-term disability worldwide and commonly results in impairments in motor function and balance. These balance deficits limit a patient’s ability to perform functional activities such as walking, stair climbing, and transfers, thereby increasing the risk of falls and reducing independence. Postural control depends on proper coordination of sensory input and muscle activation. The lumbar spine and pelvis provide structural stability, while trunk muscles such as the abdominals, hip flexors, hip extensors, and erector spinae play an important role in maintaining trunk alignment and balance. Therefore, improving trunk stability is essential in stroke rehabilitation.

In the present study, the pre-test mean BBS score was 34.40 ± 5.77 in Group I and 35.07 ± 5.42 in Group II, showing that both groups had similar balance levels before intervention. After treatment, the post-test mean improved to 38.13 ± 5.77 in Group I and 42.60 ± 6.21 in Group II. The results indicate that both Frenkel’s exercises and lumbar stabilization exercises were effective in improving balance in stroke patients. However, patients who underwent lumbar stabilization exercises with the PNF technique showed greater improvement in balance compared to those who performed Frenkel’s exercises.

Park and Shin (2012) reported that lumbar stabilization exercises combined with PNF techniques significantly improved dynamic balance and gait performance in chronic stroke patients. Alhwoaimel (2018) demonstrated that trunk exercises had a significant positive effect on trunk performance after stroke.

Yang (2021) and Shim et al. (2014) also showed that trunk stabilization exercises improve trunk muscle activity and balance ability in stroke patients. Verheyden et al. emphasized that improvement in proximal trunk control plays a key role in enhancing balance.

Thus, the results of the present study are consistent with existing literature, confirming that lumbar stabilization exercises with PNF techniques are more effective in improving balance among stroke patients.

CONCLUSION

The present study provides evidence supporting the effectiveness of both Frenkel’s exercises and lumbar stabilization exercises in improving balance among post-stroke patients. However, the results demonstrated that lumbar stabilization exercises combined with PNF techniques produced significantly greater improvement in balance as measured by the Berg Balance Scale. The statistical analysis revealed a significant difference between the two groups in post-test scores, indicating superior outcomes in the lumbar stabilization with the PNF group.

The enhanced trunk stability, improved neuromuscular coordination, and better postural control achieved through lumbar stabilization with PNF techniques may have contributed to this greater improvement. Therefore, it can be concluded that lumbar stabilization exercises using PNF techniques are more effective than Frenkel's exercises in improving balance in post-stroke patients and can be recommended as an effective intervention in stroke rehabilitation.

LIMITATIONS OF THE STUDY

1. The sample size was relatively small (30 subjects), which may limit the generalization of the findings to a larger population.
2. The duration of the intervention was short, and long-term follow-up was not conducted to assess sustained effects.
3. Only balance was measured using the Berg Balance Scale; other functional outcomes, such as gait speed, muscle strength, and quality of life, were not assessed.
4. The study included patients within a specific age group, which may limit applicability to younger or older stroke populations.
5. External factors such as home exercise compliance and daily activity levels were not monitored.

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