



# The Effect of Frenkel's Exercise with PNF on Functional Reach in Stroke Survivors: A Randomized Control Trial

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## Research Article

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## Abstract

**Background & Purpose:** Stroke is a condition that is highly vulnerable and has a high worldwide prevalence rate. This study investigates the effects of Frenkel's Exercise combined with Proprioceptive Neuromuscular Facilitation (PNF) techniques on functional reach in stroke patients.

**Methods:** A total of 100 participants aged 40-60 years, who had experienced a stroke at least six months prior, were randomly assigned to two intervention groups: Group A (Frenkel's Exercises) and Group B (Conventional Exercises). Over an 8-week period, participants engaged in supervised exercise sessions three times a week. Pre-intervention and post-intervention assessments were conducted using the Modified Functional Reach Test (MFRT), to measure changes in functional reach.

**Results:** The Result of the study revealed that both of the group showed significant improvement in functional reach ( $p < 0.05$ ). However, Group A (Experimental Group) had statistically better functional reach improvement compared to Group B (Control Group).

**Conclusion:** These findings suggest that incorporating Frenkel's Exercises with PNF techniques can effectively enhance functional reach in stroke survivors.

**Keywords:** Frenkel's Exercise; Functional Reach; Proprioceptive Neuromuscular Facilitation; Stroke Survivors

## Abbreviations

PNF: Proprioceptive Neuromuscular Facilitation; WHO: World Health Organization; MFRT: Modified Functional Reach Test.

## Introduction

The definition of stroke according to the World Health Organisation as it is a clinical Syndrome of focal or global disturbance of cerebral function, lasting more than 24



hours or leading to death, with no apparent cause other than vascular origin [1]. Postural instability is a major complication in stroke survivors.

Frenkel's exercises are set of exercise developed by Dr. H. S. Frenkel. These exercises aim at establishing voluntary control of movement by the use of any part of sensory mechanism which remained intact, notably sight, sound and touch, to compensate for the loss of kinaesthetic sensation. These exercises aimed to educate the central nervous system through precise repetition of exercises, especially the lower limbs, with a high level of concentration. The exercises are executed in three distinct positions: lying, sitting and standing [2,3]. Proprioceptive Neuromuscular Facilitation (PNF) is a method of stretching technique used to enhance the muscle flexibility has been proven to increase both active and passive range of motion [4]. Autogenic inhibition, reciprocal inhibition, stress relaxation and the gate control theory are the four theoretical physiological mechanisms that have been identified to increase range of motion [5,6].

Literatures have shown implementation of coordination and proprioception training can improve functional reach among various populations. The evidences suggests that Frenkel's exercise can be advantageous for patients balance recovery, coordination, reaction time and decreasing sensory dysfunction, ataxia and fatigue [3-7].

### Need of the Study

The need for this study comes from the significant challenges faced by stroke survivors, particularly in terms of postural instability and functional mobility. According to the World Health Organization, stroke is defined as a clinical syndrome resulting from a disturbance in cerebral function, which can lead to long-term disabilities, including impaired balance and coordination [2]. Postural instability is a major complication that affects the quality of life and independence of stroke survivors, making effective rehabilitation strategies essential.

Frenkel's Exercises, developed by Dr. H. S. Frenkel, are specifically designed to enhance voluntary control of movement by utilizing intact sensory mechanisms such as sight, sound, and touch. These exercises focus on educating the central nervous system through precise and repetitive movements, particularly targeting the lower limbs [2]. The integration of Proprioceptive Neuromuscular Facilitation (PNF) techniques, which have been shown to improve muscle flexibility and range of motion, further supports the rehabilitation process [3].

Research indicates that coordination and proprioception training can significantly enhance functional reach among

various populations, including stroke survivors [3]. Given the prevalence of stroke and its associated complications, there is a pressing need to explore and validate effective rehabilitation methods that can improve balance, coordination, and overall functional mobility in this population.

In summary, the study fills the critical gap in rehabilitation practices for stroke survivors by investigating the combined effects of Frenkel's Exercises and PNF techniques on functional reach, thereby contributing to improved therapeutic strategies and outcomes for individuals recovering from stroke [8].

### Methodology

The study was conducted using a randomized controlled design. Local rehabilitation centers, hospitals and community health centers were the sources of recruitment for participants. Participants who are screened and showed interest in the study were invited to participate after meeting the inclusion and exclusion criteria.

### Participation Selection

The study entails participants having a confirmed stroke diagnosis since 6 months, being aged 40-60 years, lower extremity Brunnstrom motor recover stage 4 and above, MMSE score: 24-30, able to sit and stand alone or with minimal assistance and able to understand and follow therapist's instructions.

The study excluded individuals with severe cognitive impairment, other neurological conditions, severe comorbidity, or recent surgery to prevent complications during the study. Participants with cognitive deficits, other neurological disorders, severe cardiovascular, respiratory, or musculoskeletal conditions, or those who had undergone any surgical procedures within the last 3 months were excluded.

### Procedure

After informed consent participants underwent an initial assessment to evaluate their baseline functional reach and overall functional mobility. A total of 100 numbers of hemiplegic participants subjects were randomly assigned into two groups (50 each):

**Group A (Experimental Group):** Frenkel's Exercises with PNF techniques.

**Group B (Control Group):** Conventional Exercises with PNF techniques.

Both groups participated in the exercise sessions three times a week, for duration of 8 weeks during June 2018 to December 2021. Each session lasted approximately 60

minutes, including warm-up, exercise, and cool-down phases. Participants in the Group A (Experimental Group) performed a series of Frenkel's Exercises in lying, sitting and standing position with a repetition of 10 times for each exercise.

### Exercise for the legs in lying

- In supine lying position the patient was instructed for hip and knee flexion and extension. During movement the heel was supported throughout and slides on plinth to a position indicated by the therapist.
- In supine lying position the patient was instructed for hip abduction and adduction. During movement the leg was fully supported throughout the smooth surface of the plinth.
- The patient in lying was instructed to raise and place the heel on Specified mark made on plinth, patients other foot or shin or the heel may be placed on the palm of the therapist's hand.
- The patient in supine lying was instructed to position the hip and knee at 90° of flexion and extension and imitate a bicycle peddling in the air.

### Exercise for legs in Sitting

- The patient in sitting with back support was asked leg stretching to slide heel to a position marked on the floor.
- The patient in sitting with back support was asked for alternate leg stretching and lifting to place heel or toe on position marked on the floor.
- The patient in stride sitting was asked to change the position to stand and vice-versa.

### Exercise for legs in Standing

- The patient in stride standing asked to transfer of body weight from one foot to another foot.
- The patient in stride standing was asked for sideways walking by placing feet on position marked on the floor.
- The patient in standing was asked for walking and placing feet on position marked on the floor.
- The patient in standing was asked to perform a 360° turn with a marking on the floor without lifting the feet from the floor.
- The patient in standing was asked for walking and changing the direction to avoid obstacles placed on the floor.

### Exercise for the Arms

- The patient in sitting with one hand supported on the table was asked for shoulder flexion or extension to place hand on a specified mark.
- The patient in the sitting position was instructed to

stretch one arm to thread it through a small ring.

- The patient in sitting was asked to pick up objects and place them down on specified marks.

### Finally PNF techniques were applied to facilitate muscle engagement and improve balance and coordination.

- Participants in the Group B (Control Group) received exercise programs included strengthening, co-ordination and balance exercise with PNF techniques. Each of the exercise was repeated for 10 times.
1. Front of the each knee strengthening exercise performed using weight cuff placed on ankle. The patient in supported sitting in a chair was instructed to lift the leg slowly, straighten the knee and then lower the feet with control.
  2. Back of the each knee strengthening exercise performed using weight cuff placed on ankle. The patient in supported standing was instructed to bend the weighted leg backward of the floor toward buttock and then slowly lower the foot to straighten the leg back to the initial position.
  3. Side of the each hip strengthening exercise performed using weight cuff placed on ankle. The patient in supported standing with feet hip width apart was instructed to lift the legs sideways slowly away from weight bearing leg and bring it back to the initial position.
  4. Knee bends; the patient in supported standing with feet hip width apart, toe facing forward was instructed to assume a squat position by bending the knees and pushing bottom backwards as going to sit down. Then reposition the body back to the initial position. Ensure that the patient doesn't lift the heels.
  5. One leg stand exercise; the patient in supported standing was instructed to lift one leg slowly of the ground, balancing the body on one leg keeping the weight bearing knee soft and upright posture for 10 seconds.
  6. Heel walking; the patient in upright supported standing posture was instructed to keep the body weight on the toes by lifting the heels off the floor and walk for 5-10 steps.
  7. Toe walking; the patient in upright supported standing posture was instructed to keep the body weight on the toes by lifting the heels off the floor and walk 5-10 steps.
  8. Sideways walking; the patient in upright supported standing posture was instructed for walking sideways and taking 5-10 steps and then walking back to the initial position.
  9. Backward walking; the patient in upright supported standing posture was instructed for walking backward and taking 5-10 steps and then walking back to the initial position.
  10. Similarly PNF techniques were integrated to enhance neuromuscular activation and improve balance and coordination.

## Functional Reach Measurement

### Modified Functional Reach Test (MFRT)

Participants in seated position are instructed to lean as far forward or laterally as much as possible without staying

off balance, while still maintaining 90 degree flexion at hip, knee and ankle with shoulder at 90 degrees. Measuring the distance reached by using a yard stick fixed against a wall Table 1.

Exercise Type	Frequency	Intensity	Time	Type
Group A (Frenkel's Exercises Combined + Proprioceptive Neuromuscular Facilitation (PNF))	3/ Week X 8 Weeks	Moderate Intensity With Intensity Adjusted Based On Individual Capability, Exercises Were Challenging With No Pain. Challenging Tasks Hold Time Exercise Duration	60 Minutes	<b>A. Frenkel's Exercises:</b> In Lying: Hip And Knee Flexion/ Extension (10 Repetitions) In Sitting: Shoulder Flexion To A Specified Mark (10 Repetitions) Reaching: Pick Up Objects (10 Repetitions) Standing: Weight Shifting From One Leg To Another (10 Repetitions) <b>B. PNF Techniques:</b> Stretching: Hold-Relax Technique for Major Muscle Groups (Hold For 10 Seconds, Relax, Then Stretch) 6. Strengthening: Resistance Exercises For Arms and Legs (10 Repetitions Each)
Group B (Conventional Exercises Combined With PNF Techniques)	3/ Week X 8 Weeks	Moderate Intensity With Intensity Adjusted Based On Individual Capability, Exercises Were Challenging With No Pain. · Challenging Tasks · Hold Time Exercise Duration	60 Minutes	<b>A. Conventional Exercises:</b> <b>Knee Strengthening:</b> 1. <b>Front of the Knee:</b> Straighten The Knee, (10 Repetitions). <b>Back of The Knee:</b> Bending the Weighted Leg Backward (10 Repetitions). <b>Side of The Hip:</b> Lift the Leg Sideways (10 Repetitions). <b>Weight Shifting:</b> Shifting Weight from One Leg to the Other. <b>Knee Bends:</b> Repetitive Squat Position (10 Repetitions). <b>Reaching Exercises:</b> <b>B. PNF Techniques:</b> In Control Group, PNF Techniques Also Included During Their Exercise Sessions, Which Included -Stretching & Strengthening

**Table 1:** Exercise Dosimetry.

### Statistical Analysis

Means, standard deviations, and ranges were calculated for demographic variables (age, gender) and baseline measurements (functional reach) for both intervention groups.

Independent t-tests: Used to compare the mean functional reach scores between Group A (Frenkel's exercise)

and Group B (conventional exercises) at baseline.

Paired t-tests: Conducted to compare pre and post-intervention functional reach scores within each group, assuming normal distribution.

A p-value of <0.05 was considered statistically significant for all analyses. Statistical analyses were performed using SPSS 24.0 software.

## Results

Both of the groups (group A and B) were comparable in terms of demographic characteristics (age, gender) and baseline measurements of functional reach (Tables 2-5).

Characteristics		Experimental Group(A)	Control Group (B)
Mean age (years)		50.64	48.88
Standard deviation		5.83	5.72
Gender	Male	30	28
	Female	20	22

**Table 2:** Demographic Details

Experimental Group	N	Mean	SD	t-Value	p-Value	Remarks
Pre-intervention	50	31.46	1.59	-62.97	0	As p<0.05, there is a significant difference between the pretest and posttest values.
Post-intervention	50	44.54	1.35			

**Table 3:** Comparison of pre-intervention and post-intervention values within Experimental Group

Control Group	N	Mean	SD	t-Value	p-Value	Remarks
Pre-intervention	50	31.14	1.71	-27.7	0	As p<0.05, there is a significant difference between the pretest and posttest values.
Post-intervention	50	37.38	1.83			

**Table 4:** Comparison of pre-intervention and post-intervention values within Control Group

Group	N	Mean	SD	t-Value	p-Value	Remarks
Experimental	50	13.08	1.5	21.909	0	As p<0.05, there is a significant difference between the two groups.
Control	50	6.24	1.6			

**Table 5:** Comparison of pre-intervention and post-intervention values between Experimental Group and Control Group

## Functional Reach Improvements

There was a statistically significant increase in Functional Reach from pre-intervention to post-intervention ( $p < 0.05$ ) in both the groups.

## Between-Group Comparison

Post-intervention, Group A demonstrated a greater improvement in functional reach compared to Group B ( $p < 0.05$ ).

## Discussion

The study wanted to find the impact of Frenkel's Exercises plus Proprioceptive Neuromuscular Facilitation (PNF) techniques on functional reach in stroke patients. The findings indicated a significant improvement in functional reach from pre-treatment to post-treatment in both groups, with Group A (the experimental group) showing more improvements in comparison to Group B (the control group) [6].

## Importance of Functional Reach

Functional reach is an important measure of balance and mobility, especially in stroke survivors who usually experience postural instability. The ability to reach forward without loss of balance is essential for daily activities and overall self-resiliency. The results of this study align with previous literature that highlights the benefits of targeted exercise interventions in enhancing balance and functional mobility in stroke populations [3,6].

## Frenkel's Exercises and Their Mechanism

Frenkel's Exercises are designed to improve voluntary control of movement by utilizing existing sensory mechanisms, like vision, sound, and touch, to compensate for the loss of kinesthetic sensation. These exercises focus on exact repetition and concentration, which are crucial for re-exercise the central nervous system [2]. The study found out the support for notion that Frenkel's Exercises can improve both static and dynamic balance, coordination, and reaction time, which are mainly important for trunk control and functional ability [3,6].

The application of PNF further helps Frenkel's Exercises by facilitating motor coordination and improving functional outcomes. PNF will help activate neuromuscular skeletal integration through proprioceptive stimuli, which can enhance muscle engagement and improve balance [2,6]. The combination of above approaches appears to create a synergistic effect, leading to more significant increase in functional reach in comparison to conventional exercises alone.

### Comparison with Control Group

In control group, which involved in conventional exercises with PNF, also showcased improvements in functional reach, but these were not as pronounced as those in the experimental group. This suggests that while conventional exercises can be beneficial, the specific focus on Frenkel's Exercises may provide additional advantages in retraining motor control and enhancing balance [6,9]. The findings are consistent with previous studies that have demonstrated the effectiveness of coordination and proprioception training in improving functional reach among various populations, including stroke survivors [3].

### Limitations and Future Directions

While the study provides valuable insights, it is essential to acknowledge its limitations. The sample size, although adequate, may not fully represent the broader stroke survivor population. Additionally, the study's duration of 8 weeks may not be sufficient to observe long-term effects of the interventions. Future research could explore longer intervention periods and larger sample sizes to validate these findings further [10-12].

Moreover, incorporating qualitative measures, such as participant feedback on their perceived improvements in balance and mobility, could provide a more comprehensive understanding of the interventions' impact. Investigating the effects of these exercises on different subgroups of stroke survivors, such as those at varying stages of recovery, could also yield valuable insights.

### Conclusion

In conclusion, the study demonstrates that incorporating Frenkel's Exercises with PNF techniques can effectively enhance functional reach in stroke survivors. The findings underscore the importance of targeted rehabilitation strategies in improving balance and mobility, ultimately contributing to better functional outcomes and quality of life for individuals recovering from stroke [2-3].

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