A Comparative Study On Effectiveness Of Pelvic Proprioceptive Neuromuscular Facilitation and Dual Task Training on Dynamic Balance in Standing and Sitting in Chronic Stroke Patients

By

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In Partial fulfilment

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MASTER OF PHYSIOTHERAPY (M.P.T)

In

NEUROLOGY

Under the guidance of

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2023-2025

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DECLARATION BY THE CANDIDATE

I hereby declare that this dissertation entitled "**A Comparative Study On Effectiveness of Pelvic Proprioceptive Neuromuscular Facilitation and Dual Task Training on Dynamic Balance in Standing and Sitting in Chronic Stroke Patients**" is a Bonafide and genuine research work carried out by me under the guidance of **Dr. Asifuzzaman Shahriyar ahmed (PT)**, Associate Professor of ABSMARI, **Dr. Partha Ranjan Das (PT)** Senior Assistance Professor of ABSMARI.

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LIST OF ABBREVIATIONS

- ABSMARI – Abhinav Bindra Sports Medicine and Research Institute
- PNF – Proprioceptive neuromuscular fascilitation
- DT – Dual task
- FRAT- Functional Reach Arm test
- L/E – Lower extremity
- SPSS – Statistical package for social science
- MD- Mean Difference
- SD- Standard Deviation

ABSTRACT

Background- Stroke is the second leading reason for death and the third most common reason for disability. Stroke is a source of possible substantial harm and is often more disabling than lethal. Common stroke defects include stiffness, tiredness, loss of balance on the afflicted side, resulting in an inability to sustain postural alignment. Pelvic proprioceptive neuromuscular facilitation (PNF) is a physical rehabilitation that combines functionally dependent diagonal activity patterns with neuromuscular facilitator strategies to improve motor behaviour, endurance, and muscle activity and control. Chronic stroke patients often have great difficulty with performing dual-tasks while standing or walking and reduced dual-tasking ability has significant effects on patients' mobility, safety, and daily functioning, also increase fall hazard .This protocol was created to describe the experimental study design for comparating effect of pelvic PNF and Dual task exercises in chronic stroke patients to improve dynamic balance .

Objective- To assess which intervention strategy leads to greater improvement in dynamic balance for both sitting and standing position on functional reach test

Method- The participants (n=38) were stroke survivors who fulfilled the inclusion criteria for research and were divided into two groups. The regimen lasted three weeks and took 30 minutes each day. Patients were evaluated at the beginning and end of their treatment. In both groups, pre- and post-intervention outcome measures functional reach arm test and mini-bestest were recorded and the data was analyzed.

RESULT - A total of 38 chronic stroke patients were divided into two groups: Pelvic PNF (n=20) and Dual Task training (n=18). Both groups underwent 30-minute daily

sessions for three weeks. Significant improvement in dynamic balance was observed in both groups. The Pelvic PNF group improved from 12.65 ± 2.08 to 18.50 ± 1.39 on the Functional Reach Test, while the Dual Task group improved from 12.89 ± 2.78 to 18.33 ± 1.94. In standing Functional Reach, Group 1 increased from 15.76 ± 3.07 to 19.52 ± 5.13, and Group 2 from 16.53 ± 1.50 to 19.86 ± 4.48**.** Mini-BESTest scores also improved, with Group 1 increasing from 16.55 ± 2.41 to 20.1 ± 2.43, and Group 2 from 16**.**44 ± 2**.**43 to 20.88 ± 3.12**.** Statistical analysis showed no significant difference between the groups post-intervention, indicating that both interventions were equally effective in improving dynamic balance.

CONCLUSION - The study concluded that both the groups receiving pelvic PNF group 1 and dual task training group 2 had similar effect of dynamic balance . Both group improved dynamic balance in functional reach arm test and MINI BESTesT . Both intervention shown improvement but there is significant difference within the group.

KEYWORDS – Chronic stroke ; pelvic neuromuscular fascilitation ; arm test ; standing

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INTRODUCTION

Stroke is a common neurological disorder, representing a major cause of disability. It isconsidered as a significant health problem, which needs an unremitting and wide-ranging rehabilitation [1].].Stroke is also known as “cerebral vascular accident”, “brain attack” or “apoplexy” [2,3]. According to WHO stroke is defined as “acute onset of neurological dysfunction due to abnormality in cerebral circulation with resultant signs and symptoms that corresponds to involvement of focal area of brain lasting more than 24 hours”[4].

Stroke is defined as "rapid growing clinical signs of localized disruption of brain activity, with complaints persisting 24 hours or more or fatal consequences, with no evident explanation other than the vascular origin" [5]. In India, stroke is the most widely recognized reason for mortality and disability; the estimated updated overall prevalence of stroke in impoverished areas is 84-262/100,000, while in metropolitan centres it is 334-424/100,000 [6].

According to recent demographic estimates, the prevalence rate is 119-145/per 100,000 people [6].

The pelvic region is recognized as a vital critical location during static and dynamic postural shifts, allowing the body to retain momentum and modify weight variations [7]. Brunnstrom discovered, after studying a significant number of hemiplegic patients, that an almost stereotyped series of events occur during rehabilitation following a cerebrovascular injury [8].

There are several techniques and interventions suggested for stroke patients such as proprioceptive neuromuscular facilitation (PNF), strength training programs, task-

oriented training, training with visual feedback, a sensory-motor training program, balance training, robotic-assisted locomotor training, locomotor training, Intervention to manage spasticity like PNF, application of a cold pack, massage, electrical stimulation, etc. [8]PNF stands for proprioceptive neuromuscular facilitation, any of the sensory receptors that offer information about the body's movement and location are referred to be proprioceptive, the term "neuromuscular" describes both nerves and muscles are involved, facilitation is the method of developing smoother patterns [9]. PNF is a physical rehabilitation technique that combines functionally dependent diagonal activity patterns with neuromuscular facilitator strategies to improve motor behaviour, endurance, and muscle activity and control [10]. The discovery of this approach was made possible by Kabat, Knott, and Voss' revolutionary work in the 1940s and 1950s [10]. Interpersonal feedback is used in conjunction with some PNF procedures, such as joint approximations, traction, irradiation, and overflow, to enhance muscle activation and motor performance [11].

Pelvis is a part of trunk that supports extremity motions. Hence, the pelvic motion comes from trunk muscles. The range of motion in the pelvic patterns depends on the amount of motion in the lower spine. Biomechanically it is impossible to move the pelvis without motion in the spine as it is connected with the spine. Specific pelvic patterns of Proprioceptive Neuromuscular Facilitation (PNF), which are mentioned in the literature not only exercise the pelvis motion and stability but also facilitate trunk motion and stability. In addition, these patterns help to improve functional trunk activities and treat the upper trunk & cervical areas indirectly through irradiation [12].

Performing two or more tasks constantly and simultaneously or performing one task while simultaneously performing another task is referred to as “Dual-task performance” [13].

Dual tasks fall into two main groups: motor dual tasks, which require performance of a motor task and a postural control task at the same time; and cognition dual task which require performance of a cognition task and postural control task at the same time. Both types of dual task are noted as ways of training patients with neurological damage to recover their motor control ability.[14]

Stroke patients often have great difficulty with performing dual-tasks while standing or walking and reduced dual-tasking ability has significant effects on patients' mobility, safety, and daily functioning, also increase fall hazard[15].

Dual-tasking training requires subjects to simultaneously perform complex tasks, for example motor and cognitive tasks, allowing them to improve their coordination of various tasks [16]. Cognitive-motor tasks are important for various ADL, such as walking while holding a conversation. Additionally, dual tasks can be two motor tasks to allow for different motor processes to occur simultaneously to further stimulate the damaged brain (Liu et al. 2018).[17]

The Functional Reach is defined as the maximal distance one can reach forward beyond arm's length while maintaining a fixed base of support in the standing position).[18]

motor impairment increased as balance ability declined as measured by the Functional Reach. [19]

The subject performs the Functional Reach with only the arm close to the wall reaching forward and can employ any movement strategy with his upper extremity, provided the arm stays parallel to and at the level of the secured 48-inch ruler. [19]

The miniBESTest was developed using factor analysis to identify the items of the BESTest that represented dynamic balance. Rasch analysis was thenused to improve the rating categories and eliminate some items [20].

The mini-BESTest is a 14-item test of dynamic balance that includes tasks from the BESTest subsystems ‘anticipatory postural adjustments’, ‘postural responses’, ‘sensory orientation’ and ‘stability in gait’ [20]. Each item is scored from 0 to 2 points resulting in a total score out of 28 points with higher scores indicating better balance.

RESEARCH GAP

Chronic stroke patients often experience significant impairments in dynamic balance, both in sitting and standing positions, which negatively impacts their functional mobility and quality of life. Pelvic Proprioceptive Neuromuscular Facilitation (PNF) has shown promise in improving balance by facilitating neuromuscular coordination and enhancing postural control. On the other hand, dual-task training, which involves performing cognitive tasks while maintaining physical tasks, has demonstrated potential in improving motor function and cognitive processing simultaneously.

While individual benefits of pelvic PNF and dual-task training are well documented, there is a limited understanding of the comparative effectiveness of these approaches when combined or separately in improving dynamic balance. Additionally, studies evaluating their impact on dynamic balance in both sitting and standing postures in chronic stroke patients are sparse

NEED OF THE STUDY

By comparing effectiveness of pelvic PNF and dual task training , physiotherapists can develop more targeted and efficient rehabilitation programs to improve dynamic balance in chronic stroke patients , ultimately ehancing their independence and quality of life.[3]

Studies on pelvic PNF have been compared to studies that are not very adequate or comparable directly with pelvic PNF. Additionally, studies based on group divisions and numerous limitations have led to the conclusion that in order to assess the usefulness and efficacy of pelvic PNF it is best to compare it to more dependable studies that have demonstrated greater efficacy in other population studies[8]

Refinement of Techniques: Comparative studies can highlight difficulties in the application of each intervention , leading to refinements in technique and potentially improving overall patient outcomes.

AIM AND OBJECTIVE

AIM

To investigate Pelivc PNF and Dual Task training which strategy leads to greater improvement in dynamic balance for patients both in sitting and standing.

OBJECTIVE

To assess which intervention strategy leads to greater improvement in dynamic balance for both sitting and standing position on functional reach test.

HYPOTHESIS

null hypothesis

There is no significant difference between pelvic pnf and dual task training on dynamic balance in sitting and standing for chronic stroke patients

alternative hypothesis

There is significant difference between pelvic pnf and dual task training on dynamic balance in sitting and standing for chronic stroke patients

REVIEW OF LITERARTURE

1. **Hayy Y Patni (2019)A COMPARATIVE STUDY ON THE EFFECTS OF PELVIC PNF EXERCISES AND HIP EXTENSOR STRENGTHENING EXERCISES ON GAIT PARAMETERS OF CHRONIC HEMIPLEGIC PATIENTS**. 30 subjects were conveniently divided into either of the two groups namely Pelvic PNF Group (Group A) and Hip extensor strengthening Group (Group B).3 days a week for a total duration of 4 weeks. 40-65 years of age. This study concludes that pelvic Proprioceptive Neuromuscular Facilitation technique is more effective than Hip extensor strengthening exercises in improving gait parameters such as stride length, gait velocity and cadence in chronic hemiplegic patients.

2. **Vishal Sharma et al (2017) Effect of core strengthening with pelvic proprioceptive neuromuscular facilitation on trunk, balance, gait, and function in chronic stroke.** Twenty-three participants with chronic stroke were recruited and randomly allocated to one of the two groups: core strengthening combined with pelvic PNF (group 1, n= 13), and pelvic PNF with trunk flexibility exercises (group 2, n= 10). Intervention was given to both groups for 60 min per session 5 times per week for 4 weeks. The results indicated that core stabilisation combined with pelvic PNF was more effective for improving trunk impairment, balance and gait of chronic stroke patients

3. **Boob et al (2022) Effectiveness of Pelvic Proprioceptive Neuromuscular Facilitation Techniques on Balance and Gait Parameters in Chronic Stroke Patients: A Randomized Clinical Trial.** patients between 40 to 75 years of age. Two groups A and B. Group A was given pelvic PNF along with task-oriented exercises for lower extremities and Group B was given only task-oriented exercises for the lower limb. Pelvic PNF along with task-oriented exercises proved to be beneficial and can

help in the restoration of balance and gait parameters as a result of normalisation in the geometry and symmetry of the pelvis in stroke patients. The pelvis, which is a connecting link between the trunk and lower limbs, plays a crucial role in balance and also in lower limb performance exclusively in gait

4. **Sana Salahuddin Rai et al (2020)Effect of 2 Weeks of Dual Task Training on Balance and Gait in Patients with Stroke: Single Group Experimental Study**study included 39 patients of stroke, age 20-60 years,The study was conducted for 5 days a week for 2 weeks. All the patients received intervention of Dual Task Training for 30 min .improvement in balance and gait which included scores of Berg Balance Scale and Functional Gait Assessment Scale

5. **YoungWoo Lee et al(2011) Effect of dual motor task training while sitting on trunk control ability and balance of patients with chronic stroke patients.** 28 subjects after 12 month post stroke participated. Divided into 2 group : dual motor task and control group n=14. both group performed conventional exercise 60min per day 5 times a week . Dual motor task group performed dual task 3 times a week. Dual motor task group showed significant improvement in trunk control ability and dynamic balance in sitting position

6. **Dual Task Training in Patients with Stroke for Improving Balance and Gait: A Systematic Review (2019)** The inclusion criteria were prospective or retrospective cohort studies, studies that included only participants with stroke leading to hemiparesis and/or along with healthy participants as control group and studies that include dual task training on balance and gait. dual task training was found to be effective in improving functional performance of the stroke patients

7. **Effect of dual motor task training while sitting on trunk control ability and balance of patients with chronic stroke patients(2011**) 28 subjects after 12 month post stroke participated. Divided into 2 group : dual motor task and control group n=14. both group performed conventional exercise 60min per day 5 times a week . Dual motor task group performed dual task 3 times a week. Trunk impairment scale ,Modified functional reach test. Dual motor task group showed significant improvement in trunk control ability and dynamic balance in sitting position
8. **Effect of 2 Weeks of Dual Task Training on Balance and Gait in Patients with Stroke: Single Group Experimental Study(2020**) study included 39 patients of stroke, age 20-60 years,
9. The study was conducted for 5 days a week for 2 weeks. All the patients received intervention of Dual Task Training for 30 min. Gait and balance was assessed by using Berg Balance Scale (BBS) and Functional Gait Assessment Scale (FGAS). mprovement in balance and gait which included scores of Berg Balance Scale and Functional Gait Assessment Scale
10. **Effect of dual tasks on balance ability in stroke patients(2015)** Forty stroke patients were divided into a dual-task training group (N = 20) and a single task training group (N = 20) randomly. [Methods] The subjects in the single-task traing group stood in a comfortable position, faced a therapist, then threw a Swiss ball back and forth. They then performed balance training in which they raised and lowered their ankles while facing forward or moved objects from one table to another. The DTG performed dual tasks, which involved performing a task on an unstable surface using a balance pad. Both groups received training 30 min per day, five times per week, for eight weeks. dual task training is more effective for increasing balance ability

METHODOLOGY

Research study design: comparative study

Study Population: Chronic Stroke Patients

Study Setting: Bhubnaeswar clinics and hospitals

Sampling Design: purposive sampling

Sampling Criteria:

Inclusion**:**

1. patients who are in period between 6month-2 years after initial stroke
2. voluntary control for UL(shoulder and elbow)& trunk and lower limb grade >=3
3. Mmt lower limb >=2
4. able to hold an object to complete the task using the non affected upper extremity
5. able to walk 10m with or without any assistive device
6. Both male and female of any age group
7. NIHSS between 6-12

Exclusion:

1. Frequent seizures disorder
2. fixed deformities or contractures in the spine and lower limb
3. Severe gait impairment
4. Patients with uncontrolled medical conditions eg severe musculoskeletal pain, uncontrolled heart disease

Materials to be used:

a. 2 chairs one with arm rest and one without

b. Duck tap and yard stick

c. Pen

d. Paper

e. Ball

f. Bowl

g. bottle

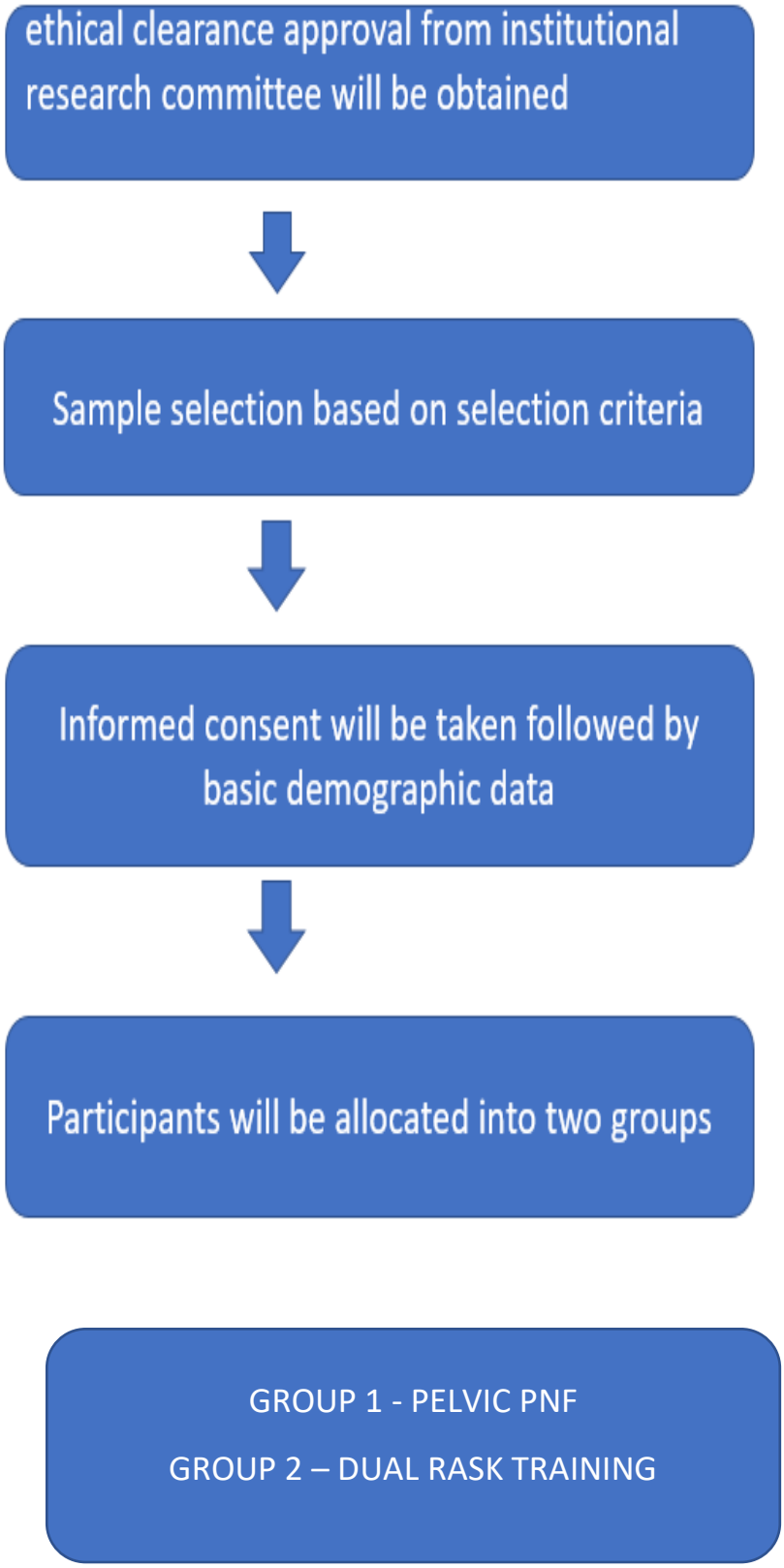
Outcome Measures:

a. FUNCTIONAL REACH TEST : ICC = 0.93 - 0.99

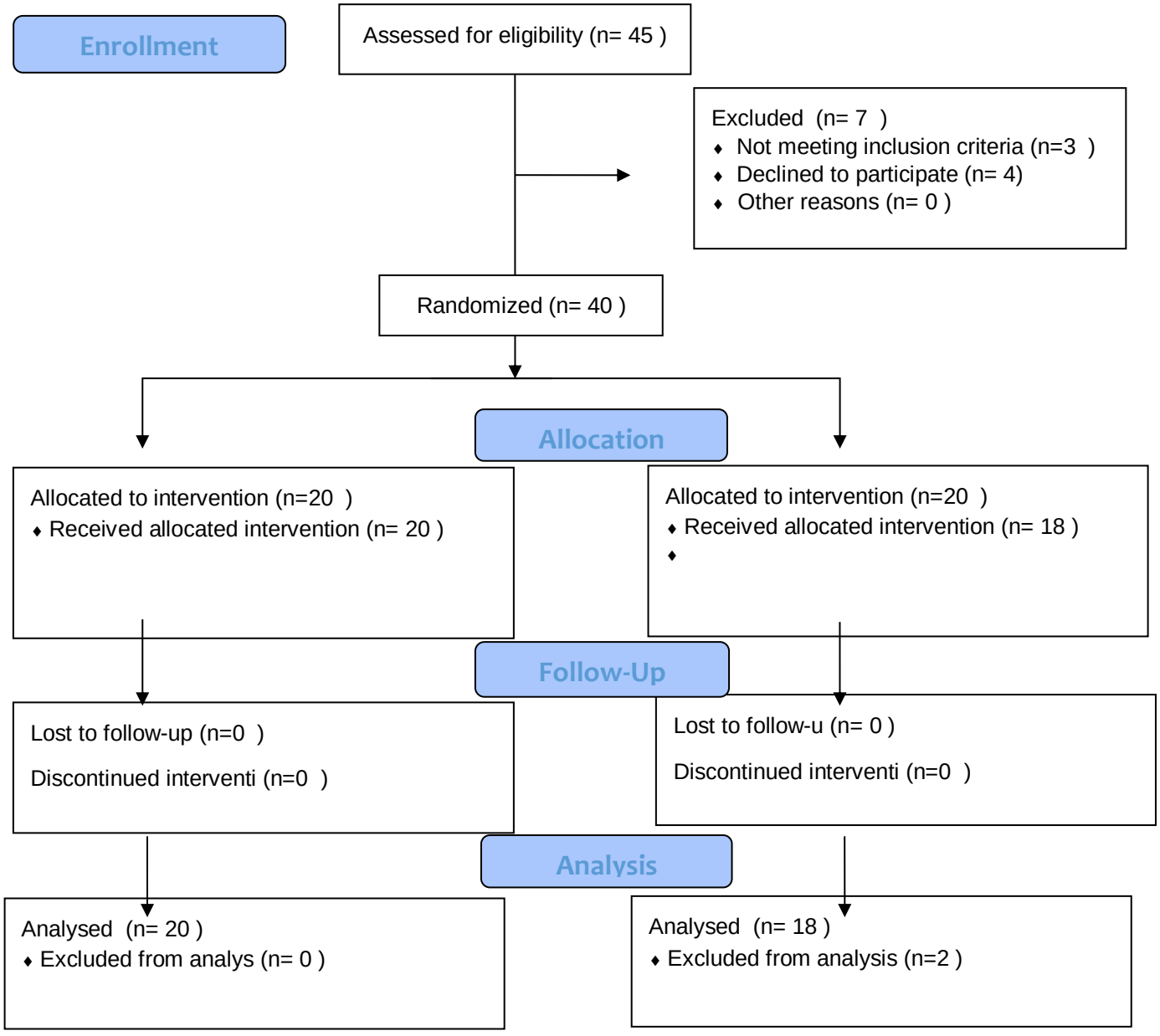
Test measures the margin of stability along with the ability to measure balance during a functional task.

b. MINI BESTesT : ICC = 0.91- 0.97

PROCEDURE


ethical clearance approval from institutional research committee will be obtained
Sample selection based on selection criteria
Informed consent will be taken followed by basic demographic data
Participants will be allocated into two groups
GROUP 1 - PELVIC PNF
GROUP 2 – DUAL RASK TRAINING

CONSORT 2010 Flow Diagram



The study consists of two groups: Group A and Group B, both undergoing pre- and post-intervention assessment using the Functional Reach Test (FRT). This test evaluates dynamic balance by measuring how far a person can voluntarily reach forward beyond arm's length while maintaining a fixed base of support. It is an effective tool to assess anticipatory postural control and functional stability in older adults.

For Group A, the treatment protocol includes a combination of Pelvic Proprioceptive Neuromuscular Facilitation (PNF) techniques and Dual Task Training. Pelvic PNF was administered based on the principles of Rhythmic Initiation, Slow Reversal (Dynamic Reversal), and Stabilizing Reversal, all applied to the agonist muscle groups using diagonal and rotational movement patterns. These techniques are aimed at improving neuromuscular control, coordination, and pelvic stability. The PNF treatment was provided at a dosage of 10 repetitions per set, with 3 sets per session, conducted 5 sessions per week over a duration of 4 weeks. Each session lasted approximately 15 to 30 minutes, depending on the participant's endurance and response to therapy.

In addition to PNF, Group A was also receive Dual Task Training designed to challenge and enhance cognitive-motor coordination. The dual tasks include activities such as walking while holding a glass of water without spilling, walking with backward counting, transferring objects while walking, and sitting while tossing a ball and reciting a song. These tasks are intended to simulate real-life multitasking scenarios and improve both balance and attentional control. The dual task exercises

will be performed for 3 repetitions, 3 sets per session, conducted 5 times per week for 4 weeks, with each session lasting between 15 to 30 minutes.

After completing the four-week intervention, a post-assessment using the Functional Reach Test was conducted for Group A to evaluate improvements in dynamic balance and postural control.

For Group B, the pre-assessment procedure is the same as Group A, involving the Functional Reach Test to establish a baseline measure of balance. The treatment for Group B includes Dual Task Training identical to that provided in Group A, comprising the four core dual task activities (glass of water, backward counting, object transfer, and ball toss with song recitation). The protocol was also follow 3 repetitions, 3 sets, 5 sessions per week for 4 weeks, with session durations ranging from 15 to 30 minutes.

In addition to dual task activities, Group B was receive Pelvic Strengthening Exercises instead of PNF. These exercises include bridging, clamshells, and hip extension, which were aimed at improving pelvic and core stability, as well as lower limb strength. Each of these exercises was performed for 5 repetitions, 3 sets, and administered 5 times per week for a period of 4 weeks, consistent with the time frame and duration of other treatment components.

At the end of the intervention period, Group B underwent post-intervention Functional Reach Test to assess any improvements in balance as a result of the treatment. The patient is instructed to stand next to, but not touching, a wall and position the arm that is closer to the wall at 90 degrees of shoulder flexion with a closed first .The assessor records the starting position at the 3rd metacarpal head on the yardstick.

Patient is instructed to reach as farther as possible without moving from the ground. The location of the 3rd metacarpal is recorded again. Score are determined by assessing the difference between the start and end position is the reach distance, usually measured in inches. Three trials are done and the average of the last two is noted.

All treatment sessions was conducted by a qualified physiotherapist to ensure correct technique and safety. A daily record of attendance, exercise performance, and participant feedback was maintained throughout the study period. Prior to the commencement of the intervention, all participants will be informed about the procedure and written consent will be obtained. Individuals with neurological, vestibular, or musculoskeletal disorders affecting balance will be excluded from the study to maintain the integrity of the results.

FIGURE 1.1 Pelvic PNF Rhythmic initiation

FIGURE 1.2 PELVIC PNF stabilizing reversal

FIGURE 1.3 CLAMPSHELL EXERCISE

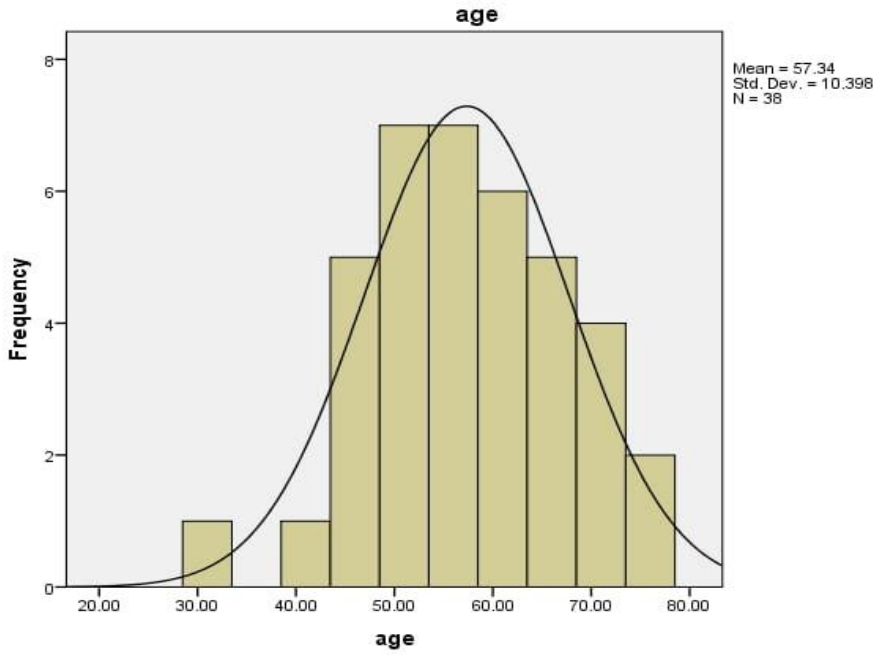
FIGURE 1.4 PELVIC BRIDGING

STATISTICAL ANALYSIS

Data was analysed using the statistical package SPSS 22.0, and the level of significance was set at $p<0.005$ Descriptivestatistics was performed to assess the mean and standard deviation of specific groups. The normality of the data was assessed using Shapiro Wilk Test. Interferential statistics to find out the within-group difference

was done using paired t-testand between the group, analysis was done using an independent t-test.

Demographic detail



shows the age distribution of participants. The data follow a normal distribution curve with a mean age of 57.34 years (SD = 10.398, N = 38). The majority of participants were within the 50–60 year age group. This indicates a relatively homogenous sample population in terms of age

Outcome Measure 1: Functional Reach Arm Test in sitting

A total of 38 participants (Group 1: n = 20; Group 2: n = 18) were included in the analysis. Table 1 shows the descriptive statistics for pre- and post-intervention dynamic balance scores.

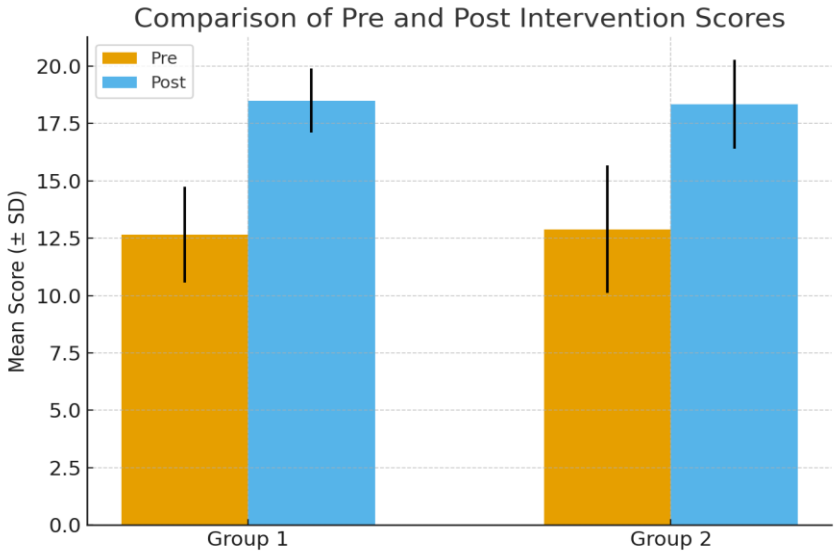
Both groups demonstrated a marked improvement in dynamic balance following the intervention. The mean pre-test score for Group 1 (Pelvic PNF) was 12.65 ± 2.08, while the post-test mean score increased to 18.50 ± 1.39. Similarly, Group 2 (Dual Task) improved from a pre-test mean of 12.89 ± 2.78 to a post-test mean of 18.33 ± 1.94.

Independent sample t-tests showed no statistically significant difference between the two groups both at baseline ($t(36) = -0.301$, $p = 0.765$) and post-intervention ($t(36) = 0.306$, $p = 0.761$), suggesting that both Pelvic PNF and Dual Task training were equally effective in improving dynamic balance in the participants.

Table 1. Descriptive Statistics of Pre- and Post-Intervention Scores

Group	Pre Mean ± SD	Post Mean ± SD	N
Group 1 (Pelvic PNF)	12.65 ± 2.08	18.50 ± 1.39	20
Group 2 (Dual Task)	12.89 ± 2.78	18.33 ± 1.94	18

Figure 1. Comparison of Pre- and Post-Intervention Scores

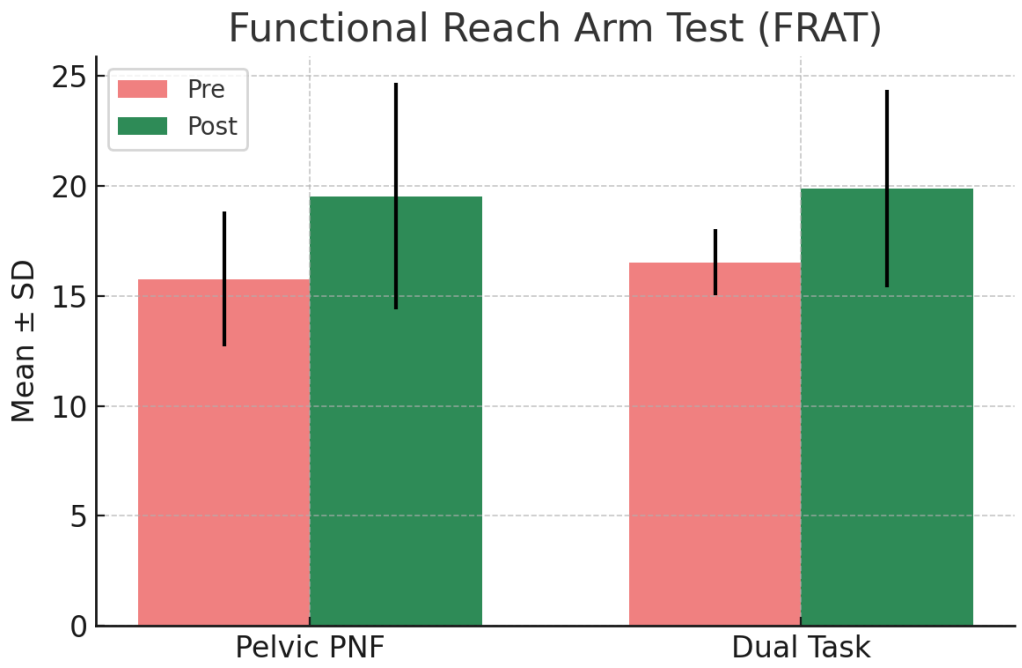


Group	Mean	SD	N
Pelvic PNF Pre	15.7647	3.0726	20
Dual Task Pre	16.5333	1.5055	18
Pelvic PNF Post	19.5294	5.1371	20

Dual Task Post	19.8667	4.486	18

Outcome Measure 1: Functional Reach Arm Test in standing

Table 2: Group statistics (Mean ± SD) for Functional Reach Arm Test.

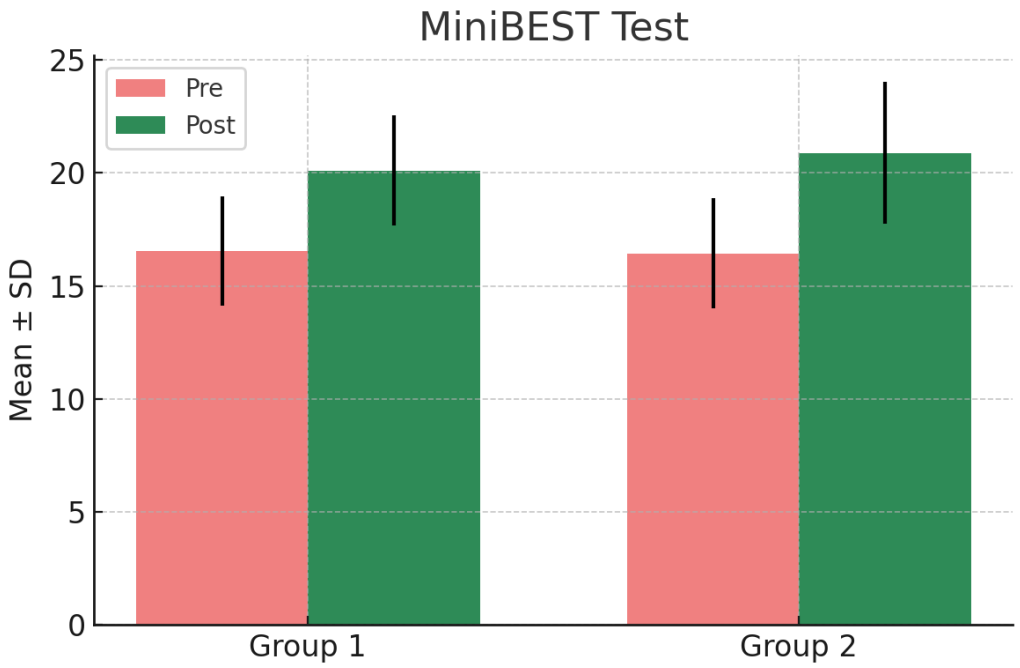


Interpretation: the descriptive statistics (Mean ± SD) for the Functional Reach Arm Test in standing. Both Pelvic PNF and Dual Task groups showed improvement from pre to post-intervention scores. The mean value for the Pelvic PNF group increased from 15.76 ± 3.07 to 19.52 ± 5.13, while the Dual Task group improved from 16.53 ± 1.50 to 19.86 ± 4.48, indicating enhancement in functional reach following the interventions.

Outcome Measure 2: Mini BEST test

Group	Mean	SD	N
wGroup 1 Pre	16.55	2.4155	20
Group 2 Pre	16.4444	2.4307	18
Group 1 Post	20.1	2.4368	20
Group 2 Post	20.8889	3.1228	18

Table 3: Group statistics (Mean ± SD) for MiniBESTest.



Interpretation: the descriptive statistics (Mean ± SD) for the Mini-BESTest scores. Both groups showed an improvement in balance performance after intervention. Group 1 showed an increase from 16.55 ± 2.41 to 20.1 ± 2.43, whereas Group 2 improved from 16.44 ± 2.43 to 20.88 ± 3.12. The results indicate that both interventions had a positive effect on dynamic balance, with Group 2 showing a slightly higher mean improvement.

Within group analysis

Paired Samples Statistics

Condition	Mean	Std. Deviation	Std. Error Mean	N
Pre	16.5	2.39	0.39	38
Post	20.84	2.49	0.4	38

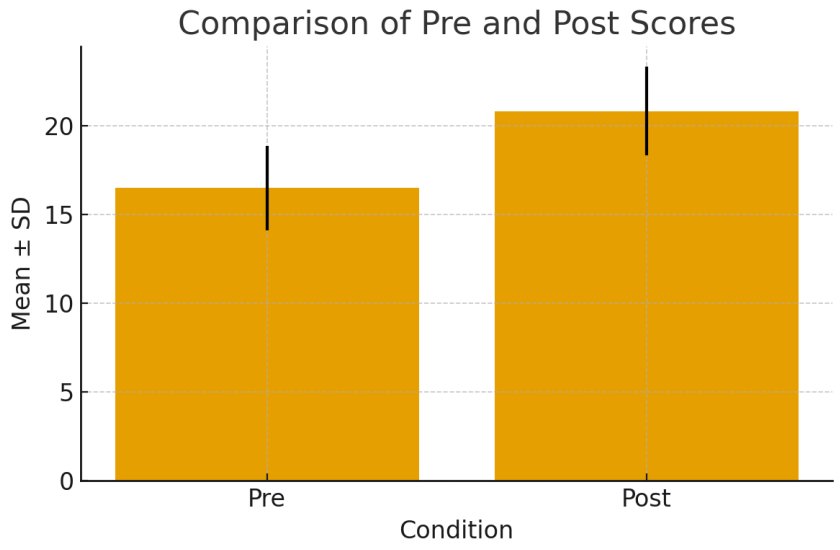
Paired Samples Correlations

N	Correlation	Sig.
38	0.454	0.004

The paired sample statistics indicate that the mean score increased from 16.50 (SD = 2.39) in the pre-test to 20.84 (SD = 2.49) in the post-test, based on 38 participants. This suggests a clear improvement after the intervention.

The paired sample correlation was r = 0.454, p = 0.004, indicating a moderate positive relationship between pre- and post-test scores.

The following graph visually represents the comparison of pre and post means:



RESULT

A total of 38 chronic stroke patients were divided into two groups: Pelvic PNF (n=20) and Dual Task training (n=18). Both groups underwent 30-minute daily sessions for three weeks. Significant improvement in dynamic balance was observed in both groups. The Pelvic PNF group improved from 12.65 ± 2.08 to 18.50 ± 1.39 on the Functional Reach Test, while the Dual Task group improved from 12.89 ± 2.78 to 18.33 ± 1.94. In standing Functional Reach, Group 1 increased from 15.76 ± 3.07 to 19.52 ± 5.13, and Group 2 from 16.53 ± 1.50 to 19.86 ± 4.48**.** Mini-BESTest scores also improved, with Group 1 increasing from 16.55 ± 2.41 to 20.1 ± 2.43, and Group 2 from 16**.**44 ± 2**.**43 to 20.88 ± 3.12**.** Statistical analysis showed no significant difference between the groups post-intervention, indicating that both interventions were equally effective in improving dynamic balance.

DISCUSSION

This study was conducted to investigate and compare the effectiveness of two targeted rehabilitation strategies—Pelvic Proprioceptive Neuromuscular Facilitation (PNF) and Dual Task Training (DTT) combined with pelvic exercises—on improving dynamic balance in both sitting and standing positions among individuals with chronic stroke. Dynamic balance is a critical component of post-stroke rehabilitation, as impairments in postural control significantly contribute to functional limitations, reduced mobility, and increased fall risk in this population. Therefore, identifying the most effective therapeutic interventions for improving balance is essential for optimizing patient outcomes and promoting independence.In this study, 32 chronic stroke patients were randomized into two intervention groups. Group 1 (n=17) received pelvic PNF techniques focused on rhythmic initiation, slow reversal, and hold-relax patterns to improve pelvic control and trunk stability. Group 2 (n=15) received a dual task training protocol that incorporated pelvic exercises alongside cognitive tasks aimed at increasing attentional demand and cognitive-motor integration. Post-intervention assessments revealed significant within-group improvements in both groups concerning dynamic balance measures in both sitting and standing. However, no statistically significant difference was found between the two groups, suggesting comparable effectiveness of both interventions in improving dynamic balance.The initial hypothesis of the study posited that the Dual Task Training (Group 2) would demonstrate superior improvements compared to pelvic PNF (Group 1), based on the theory that simultaneous engagement of cognitive and motor domains may enhance neuroplasticity and functional recovery in stroke patients. This hypothesis was grounded in literature supporting the benefits of dual task paradigms in post-stroke rehabilitation. For example, studies by Plummer et al. (2013) and Hiyamizu et al. (2012) emphasize that dual tasking can stimulate cortical reorganization through

increased cognitive-motor demand, potentially accelerating recovery in areas such as attention, working memory, and executive functioning—all of which are often compromised following a stroke.Furthermore, dual task training has been previously associated with improvements in gait speed, stride length, and balance metrics, particularly in ambulatory stroke patients (Kang et al., 2016; Kim & Park, 2016). These findings suggest that cognitive involvement during motor activities may foster more integrated neural networks, thereby enhancing balance control, especially in more complex or real-world tasks requiring divided attention.Conversely, pelvic PNF is rooted in neurophysiological principles of facilitated movement, aiming to enhance proprioception, muscle recruitment, and trunk-pelvis coordination. Given that the pelvic region acts as a central point of force transmission during postural adjustments, its stability directly influences balance in both static and dynamic tasks. PNF-based interventions have been widely validated in stroke populations, with studies showing improvements in trunk control, gait parameters, and overall functional mobility (Boob et al., 2022; Wang et al., 2014; Lee, 2016). Techniques such as slow reversal and rhythmic initiation aim to activate both agonist and antagonist muscle groups in a functional pattern, promoting sensorimotor integration and muscular synergy.The comparable outcomes between the two groups in our study could be attributed to the shared emphasis on pelvic and trunk stability, which plays a foundational role in balance control. It is plausible that both interventions, despite their different methodologies, addressed the same underlying impairments and, thus, yielded equivalent functional gains. The convergence in balance improvement, despite differing approaches, may reflect the importance of targeting core stability—whether through neuromuscular facilitation or cognitive-motor integration.

Several factors may help explain the absence of a statistically significant difference between the intervention groups:Plateau Effect in Chronic Stroke: Individuals in the chronic phase of stroke often exhibit reduced responsiveness to interventions due to stabilization of spontaneous neurological recovery. Once basic motor patterns are re-established, it may require prolonged or more intensive interventions to observe differential gains. In this context, both interventions may have been sufficient to elicit moderate improvements but not distinct enough to surpass each other significantly.Duration and Complexity of the Intervention: The dual task component may not have been sufficiently challenging or prolonged to produce additive effects beyond what was achieved through pelvic-focused PNF. Previous studies reporting the superiority of dual task training typically implement longer intervention durations and complex real-life functional tasks (e.g., obstacle navigation, conversation while walking, or memory-based tasks), which were not extensively used in our protocol. Different Mechanisms, Same Outcome: It is also possible that the interventions worked through different neurophysiological mechanisms—PNF through sensorimotor integration and motor facilitation, and dual task training through cognitive engagement and executive control mechanisms—yet led to similar functional improvements by ultimately influencing the central balance system. Sample Size: The relatively small sample size (n=32) reduces the statistical power of the analysis and limits the ability to detect small but clinically relevant differences between groups. A larger cohort would allow for more robust subgroup analyses and increase the generalizability of the findings. Heterogeneity of Participants: Variability in terms of stroke chronicity, lesion location, severity of impairment, and baseline cognitive status may have influenced responsiveness to the interventions. Such heterogeneity introduces confounding variables that can obscure true treatment effects. Future studies could benefit from

stratified randomization or matching participants on key clinical variables. No Long-Term Follow-Up: The absence of follow-up assessments prevents conclusions about the durability of the improvements. Balance improvements immediately post-intervention may not necessarily translate into long-term functional gains unless reinforced through continuous training. Limited Functional Outcome Measures: Although balance in sitting and standing positions was assessed, the study did not evaluate broader outcomes such as fall incidence, quality of life, or community ambulation, which are more directly related to the daily challenges faced by stroke survivors.

Future Directions and Clinical Implications

The findings of this study open several avenues for future research. For instance, longer-duration interventions, particularly for dual task training, could better reveal the potential superiority of cognitive-motor training over traditional neuromuscular approaches. Incorporating ecologically valid dual tasks, such as navigating virtual reality environments, walking while talking, or problem-solving during ambulation, may amplify the cognitive load and better simulate real-life challenges. Moreover, integrating gait analysis, functional MRI, or EEG-based neurofeedback could provide deeper insights into the mechanistic differences between interventions. These tools could help determine whether different brain regions are activated or reorganized during PNF versus dual task training, leading to more personalized therapy plans. Clinically, this study suggests that both pelvic PNF and dual task training are valid and effective options for improving dynamic balance in chronic stroke patients. Rehabilitation professionals can confidently employ either intervention, particularly when tailoring to patient preferences, cognitive abilities, and physical endurance.

However, for patients with cognitive deficits or dual task interference, a graded introduction of cognitive-motor challenges may be more appropriate. Lastly, future trials should aim to incorporate multi-dimensional outcome measures including activities of daily living (ADLs), participation levels, and psychosocial well-being, which will provide a more holistic evaluation of the interventions' real-world impact.

CONCLUSION

The study was conducted to evaluate and compare the effectiveness of Pelvic Proprioceptive Neuromuscular Facilitation (PNF) and Dual Task exercises on improving dynamic balance in individuals with chronic stroke. Over a three-week intervention period, both treatment protocols led to statistically significant improvements in dynamic balance, as measured by the Functional Reach Arm Test and the Mini-BESTest. The findings indicate that both interventions are effective in enhancing postural stability, functional reach, and overall balance performance in chronic stroke survivors.

Although the Dual Task group showed slightly higher mean improvements in some balance measures, statistical analysis revealed no significant difference between the two groups post-intervention. This suggests that both Pelvic PNF and Dual Task training can be used as equally effective rehabilitation strategies to improve dynamic balance in chronic stroke patients.

These results highlight the importance of incorporating targeted balance training interventions in stroke rehabilitation programs. The study supports the clinical application of both Pelvic PNF and Dual Task training, offering flexibility for therapists to choose based on patient preference, clinical setting, or specific functional goals. Future research with larger sample sizes and longer follow-up periods is recommended to explore the long-term effects and potential benefits of combining both approaches.

SUMMARY

This study aimed to compare the effectiveness of Pelvic Proprioceptive Neuromuscular Facilitation (PNF) and Dual Task training on improving dynamic balance in individuals with chronic stroke. A total of 38 participants were enrolled and divided into two intervention groups. Over a period of three weeks, each group received 30-minute daily sessions, and outcomes were assessed using the Functional Reach Arm Test and Mini-BESTest. Both groups showed significant improvements in dynamic balance from pre- to post-intervention, with no statistically significant difference between the two groups. Functional reach in both sitting and standing positions improved, and Mini-BESTest scores indicated better balance control following the interventions. Although Group 2 (Dual Task) demonstrated slightly higher post-intervention means in Mini-BESTest scores, the results suggest that both Pelvic PNF and Dual Task training protocols are effective and comparable rehabilitation strategies for enhancing dynamic balance in chronic stroke patients.

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ANNEXURE

Mini-BESTest: Balance Evaluation Systems Test

ANTICIPATORY ***SUB SCORE:*** /6

1. SIT TO STAND

Instruction: *"Cross your arms across your chest. Try not to use your hands unless you must. Do not let your legs lean against the back of the chair when you stand. Please stand up now."*

(2) Normal: Comes to stand without use of hands and stabilizes independently.
(1) Moderate: Comes to stand WITH use of hands on first attempt.
(0) Severe: Unable to stand up from chair without assistance, OR needs several attempts with use of hands.

2. RISE TO TOES

Instruction: *"Place your feet shoulder width apart. Place your hands on your hips. Try to rise as high as you can onto your toes. I will count out loud to 3 seconds. Try to hold this pose for at least 3 seconds. Look straight ahead. Rise now."*

(2) Normal: Stable for 3 s with maximum height.
(1) Moderate: Heels up, but not full range (smaller than when holding hands), OR noticeable instability for 3 s.
(0) Severe: ≤ 3 s.

3. STAND ON ONE LEG

Instruction: "Look straight ahead. Keep your hands on your hips. Lift your leg off of the ground behind you without touching or resting your raised leg upon your other standing leg. Stay standing on one leg as long as you can. Look straight ahead. Lift now."

Left: *Time in Seconds Trial 1:_____Trial 2:_____*
(2) Normal: 20 s.
(1) Moderate: < 20 s.
(0) Severe: Unable.

Right: *Time in Seconds Trial 1:_____Trial 2:_____*
(2) Normal: 20 s.
(1) Moderate: < 20 s.
(0) Severe: Unable

To score each side separately use the trial with the longest time.
To calculate the sub-score and total score use the side [left or right] with the lowest numerical score [i.e. the worse side].

REACTIVE POSTURAL CONTROL ***SUB SCORE:*** /6

4. COMPENSATORY STEPPING CORRECTION- FORWARD

Instruction: "Stand with your feet shoulder width apart, arms at your sides. Lean forward against my hands beyond your forward limits. When I let go, do whatever is necessary, including taking a step, to avoid a fall."

(2) Normal: Recovers independently with a single, large step (second realignment step is allowed).
(1) Moderate: More than one step used to recover equilibrium.
(0) Severe: No step, OR would fall if not caught, OR falls spontaneously.

5. COMPENSATORY STEPPING CORRECTION- BACKWARD

Instruction: "Stand with your feet shoulder width apart, arms at your sides. Lean backward against my hands beyond your backward limits. When I let go, do whatever is necessary, including taking a step, to avoid a fall."

(2) Normal: Recovers independently with a single, large step.
(1) Moderate: More than one step used to recover equilibrium.
(0) Severe: No step, OR would fall if not caught, OR falls spontaneously.

6. COMPENSATORY STEPPING CORRECTION- LATERAL

Instruction: "Stand with your feet together, arms down at your sides. Lean into my hand beyond your sideways limit. When I let go, do whatever is necessary, including taking a step, to avoid a fall."

Left
(2) Normal: Recovers independently with 1 step (crossover or lateral OK).
(1) Moderate: Several steps to recover equilibrium.
(0) Severe: Falls, or cannot step.

Right
(2) Normal: Recovers independently with 1 step (crossover or lateral OK).
(1) Moderate: Several steps to recover equilibrium.
(0) Severe: Falls, or cannot step.

Use the side with the lowest score to calculate sub-score and total score.

SENSORY ORIENTATION ***SUB SCORE:*** /6

7. STANCE (FEET TOGETHER); EYES OPEN, FIRM SURFACE

Instruction: "Place your hands on your hips. Place your feet together until almost touching. Look straight ahead. Be as stable and still as possible, until I say stop."

Time in seconds:_____

(2) Normal: 30 s.
(1) Moderate: < 30 s.
(0) Severe: Unable.

8. STANCE (FEET TOGETHER); EYES CLOSED, FOAM SURFACE

Instruction: "Step onto the foam. Place your hands on your hips. Place your feet together until almost touching. Be as stable and still as possible, until I say stop. I will start timing when you close your eyes."

Time in seconds:_____

(2) Normal: 30 s.
(1) Moderate: < 30 s.
(0) Severe: Unable.

9. INCLINE- EYES CLOSED

Instruction: "Step onto the incline ramp. Please stand on the incline ramp with your toes toward the top. Place your feet shoulder width apart and have your arms down at your sides. I will start timing when you close your eyes."

Time in seconds:_____

(2) Normal: Stands independently 30 s and aligns with gravity.
(1) Moderate: Stands independently <30 s OR aligns with surface.
(0) Severe: Unable.

DYNAMIC GAIT ***SUB SCORE:*** /10

10. CHANGE IN GAIT SPEED

Instruction: "Begin walking at your normal speed, when I tell you 'fast', walk as fast as you can. When I say 'slow', walk very slowly."

(2) Normal: Significantly changes walking speed without imbalance.
(1) Moderate: Unable to change walking speed or signs of imbalance.
(0) Severe: Unable to achieve significant change in walking speed AND signs of imbalance.

11. WALK WITH HEAD TURNS – HORIZONTAL

Instruction: "Begin walking at your normal speed, when I say "right", turn your head and look to the right. When I say "left" turn your head and look to the left. Try to keep yourself walking in a straight line."

(2) Normal: performs head turns with no change in gait speed and good balance.
(1) Moderate: performs head turns with reduction in gait speed.
(0) Severe: performs head turns with imbalance.

12. WALK WITH PIVOT TURNS

Instruction: "Begin walking at your normal speed. When I tell you to 'turn and stop', turn as quickly as you can, face the opposite direction, and stop. After the turn, your feet should be close together."

(2) Normal: Turns with feet close FAST (≤ 3 steps) with good balance.
(1) Moderate: Turns with feet close SLOW (≥4 steps) with good balance.
(0) Severe: Cannot turn with feet close at any speed without imbalance.

13. STEP OVER OBSTACLES

Instruction: "Begin walking at your normal speed. When you get to the box, step over it, not around it and keep walking."

(2) Normal: Able to step over box with minimal change of gait speed and with good balance.
(1) Moderate: Steps over box but touches box OR displays cautious behavior by slowing gait.
(0) Severe: Unable to step over box OR steps around box.

14. TIMED UP & GO WITH DUAL TASK ***[3 METER WALK]***

Instruction TUG: "When I say 'Go', stand up from chair, walk at your normal speed across the tape on the floor, turn around, and come back to sit in the chair."

Instruction TUG with Dual Task: "Count backwards by threes starting at ___. When I say 'Go', stand up from chair, walk at your normal speed across the tape on the floor, turn around, and come back to sit in the chair. Continue counting backwards the entire time."

ABSMARI ETHICS COMMITTEE

ABHINAV BINDRA SPORTS MEDICINE AND RESEARCH INSTITUTE,
BHUBANESWAR, ODISHA

CDSCO Reg. No.: ECR/1981/Inst/OD/24

Prof. (Dr.) E. Venkata Rao
Chairperson

Mr. Chinmaya Kumar Patra
Member Secretary

Ref. No. ABSMARI/IEC/2025/148

Date: 02/05/2025

APPROVAL LETTER
APPENDIX- VIII

To,

SHASHWAT JOSHI
ABSMARI
273, PAHAL, BHUBANEWAR-752101

Protocol Title: A Comparative Study On Effectiveness of Pelvic Proprioceptive Neuromuscular Facilitation and Dual Task Training on Dynamic Balance in Standing and Sitting in Chronic Stroke Patients

Protocol ID.: ABS-IEC-2025-PHY-074

Subject: Approval for the conduct of the above referenced study

Dear Mr./Ms./Dr **Shashwat Joshi**
With reference to your submission letter dated 06/01/2025 the ABSMARI IEC has reviewed and discussed your application for conduct of the study on dated 25/04/2025.

The following documents were reviewed and discussed

S.N.	Documents	Document (Version/Date)
1	IEC Application Form	25/04/2025
2	Informed Consent Form	25/04/2025
3	Undertaking form PI	25/04/2025
4	CRF	25/04/2025
5	COI from the Investigators	25/04/2025

The following members were present at meeting held on 25-04-2025

MEMBERS

Dr. Smaraki Mohanty
Clinician

Dr. Satyajit Mohanty
Scientific Member

Mr. Shib Shankar Mohanty
Legal Expert

Ms. Annie Hans
Social Scientist

Ms. Subhashree Samal
Lay Person

Mr. Deepak Ku. Pradhan
Scientific Member

IEC-SECRETARIAT

Mr. Gouranga Ku. Padhy
Mr. Susant Ku. Raychudamani

ABSMARI ETHICS COMMITTEE * BHUBANESWAR * Dt.....

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Prof. (Dr.) E. Venkata Rao
Chairperson

Mr. Chinmaya Kumar Patra
Member Secretary

Ref. No. ABSMARI/IEC/2025/148

Date: 02/05/2025

MEMBERS

Dr. Smaraki Mohanty
Clinician

Dr. Satyajit Mohanty
Scientific Member

Mr. Shib Shankar Mohanty
Legal Expert

Ms. Annie Hans
Social Scientist

Ms. Subhashree Samal
Lay Person

Mr. Deepak Ku. Pradhan
Scientific Member

IEC-SECRETARIAT

Mr. Gouranga Ku. Padhy
Mr. Susant Ku. Raychudamani

S.N.	Name of the Member	Designation & Qualification	Representation as per NDCT 2019	Gender (M/F)	Affiliation with the Institution (Y/N)
1	Prof. Dr. E. Venkata Rao	Professor (MBBS, MD, Dept. of Community Med.) IMS & Sum Hospital, BBSR	Chair Person	M	N
2	Dr. Smaraki Mohanty	Asst. Prof-IMS & Sum Hospital/MBBS, MD (Community Med)	Clinician	F	N
3	Mr. Shiba Sankar Mohanty	Junior Counsel-Lt. Ramachandra Sarangi's Chamber / BA LLB	Legal Expert	M	N
4	Mr. Chinmaya Kumar Patra	Principal-ABSMARI, MPT	Member Secretary	M	Y
5	Ms. Annie Hans	Disability Inclusive Development Co-Ordinator in Humanity and Inclusion (India/Nepal/Srilanka). /MA in Social Work	Social Scientist	F	N
6	Ms. Subhashree Samal	Ret. Reader-Pol Sc.	Lay Person	F	N
7	Mr. Deepak Kumar Pradhan	Asst. Prof-ABSMARI, MPT	Scientific Member	M	Y

This is to confirm that only members who are independent of the Investigator and the Sponsor of the trial have voted/ provided opinion on the trial.

This Committee approves the documents and the conduct for the study in the presented form with necessary recommendation.

The ABSMARI IEC must be informed about the progress of the study in the prescribed format attached, any SAE occurring in the course of the study, any changes in the protocol and patient information/informed consent/assent and request to provide a copy of the final report.

The ABSMARI IEC follows procedures that are in compliance with the requirements of ICH (International Conference on Harmonization) guidance related to GCP (Good Clinical Practice) and applicable Indian regulations.

Yours sincerely,

Mr. Chinmaya Kumar Patra
Member Secretary
ABSMARI Ethics Committee
Pahal, Bhubaneswar

Member Secretary
ABSMARI ETHICS COMMITTEE

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2

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Shaswat Joshi

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INFORMED CONSENT

STUDY TITLE: A Comparative Study On Effectiveness of Pelvic Proprioceptive Neuromuscular Facilitation and Dual Task Training on Dynamic Balance in Standing and Sitting in Chronic Stroke Patients"

Study IEC registration Number: ABSMARI/IEC/2025/148
Subject‘s Name: _____
Age: _____
Address of the Subject_____
Occupation: _____

(by subject) –

- I confirm that I have read and understood the information sheet dated _____ for the above study and have had the opportunity to ask questions. [ ]
- I understand that my participation in the study is voluntary and that I am free to withdraw at any time, without giving any reason, without my medical care or legal rights being affected. [ ]
- I understand that the Sponsor of the clinical trial, and others working on this. [ ] Sponsor ‘s behalf, the Ethics Committee and the regulatory authorities will not need my permission to look at my health records both in respect of the current study and any further research that may be conducted in relation to it, even if I withdraw from the trial. I agree to this access. However, I understand that my identity will not be revealed in any information released to third parties or published.
- I agree not to restrict the use of any data or results that arise from this study provided such a use is only for scientific purpose(s). [ ]
- I agree to take part in the above study. [ ]

Signature (or Thumb impression) of the Subject
Date: _____/ ____/ _____
Signatory‘s Name:

Signature of the Investigator:
Date: _____/ ____/ _____
Study Investigator‘s Name:

Signature of the Witness (from study setting):
Date: ____/ _____/ _____
Name of the Witness:

Master chart excel

Name	Age	Stroke Duration	Group	Post	pre
Vikash	45	8 months	Pelvic PNF	25	15
Sasmita	46	1 year	Pelvic PNF	22	13
Debasis	48	2 years 3 months	Pelvic PNF	23	13
Sangita	50	6 months	Pelvic PNF	25	15
Prakash	52	4 years	Pelvic PNF	21	14
Jharana	55	3 years 6 months	Pelvic PNF	23	13
Sarat	57	2 years	Pelvic PNF	23	13
Ipsita	59	5 years	Pelvic PNF	25	13
mohan das	60	1 year 6 months	Pelvic PNF	20	15
Gitanjali	61	3 years	Pelvic PNF	21	13
Subhash	63	9 months	Dual Task	25	16
Anita	65	2 years 8 months	Dual Task	21	17
Manas	66	1 year 3 months	Dual Task	21	16
Smita	67	4 years 4 months	Dual Task	23	16
Abinash	68	1 year	Dual Task	22	16
Laxmi	69	3 years 2 months	Dual Task	21	16
Sudarshan	70	2 years 5 months	Dual Task	24	16
Bijay	49	6 months	Dual Task	23	16
Gopal	53	4 years 9 months	Dual Task	20	16
Rashmita	58	5 years	Dual Task	22	17
subhash	49	3yrars	pelvic pnf	21	16
hari krushna	49	2.5years	pelvic pnf	22	15
rautra	70	4years	Dual Task	20	15
banambar palia	55	5years	Dual Task	21	14
kuntik swain	31	8month	pelvic pnf	14	22
soumya	44	2years	Pelvic PNF	12	20
amit sahoo	41	3.5years	Dual Task	13	20
Sumit	61	4 years	Pelvic PNF	10	18
sahoo suraj	51	5years	Dual Task	11	18
Preeti	57	5years	Pelvic PNF	12	19
pragya	61	4 years	Dual Task	11	19
sudhir	45	3.5years	pelvic pnf	13	21
Patient Number	MAS	Strength	Mini BESTest	MMSE	Mini BESTest post
Vikash	1	1	13	15	20

Sasmita	2	1	18	13	22
Debasis	1+	2	19	15	20
Sangita	1	3	16	16	18
Prakash	2	1	18	21	20
Jharana	1	1	13	20	19
Sarat	1+	3	17	18	22
Ipsita	2	1	20	18	24
mohan das	1+	1	14	22	17
Gitanjali	1+	3	18	14	23
Subhash	2	1	19	21	26
Anita	2	2	19	17	22
Manas	2	2	14	16	21
Smita	1+	3	16	21	19
Abinash	1	1	20	14	23
Laxmi	2	3	18	22	23
Sudarshan	2	1	14	14	20
Bijay	2	1	18	14	22
Gopal	1	2	17	18	20
Rashmita	2	2	14	19	19
subhash	2	3	13	21	18
hari krushna	1+	3	13	15	18
rautra	1+	2	16	18	22
banambar palia	2	1	15	22	21
kuntik swain	2	3	20	19	24
soumya	2	1	20	19	26
amit sahoo	1	1	20	22	24
Sumit	2	3	18	14	20
sahoo suraj	1	3	17	23	24
Preeti	1+	3	15	16	20
pragya	1	3	19	14	24
sudhir	1	3	14	21	17
Ramesh	2	2	15	17	19
Suddha	2	2	18	23	24
Reshma	1+	3	13	15	18
Rajunath	2	1	17	21	24
Parima	2	2	15	19	20