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Original Research Article

Effect of Goal Oriented Dual Task Training Versus Proprioceptive Neuromuscular Facilitation on Balance and Gait in Post Stroke Subjects

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ABSTRACT

BACKGROUND AND OBJECTIVE: Balance and gait disturbances frequently occur following a stroke. The objective of this study was to compare the effect of goal oriented dual task training combined with conventional physiotherapy versus Proprioceptive neuromuscular facilitation combined with conventional physiotherapy for improving balance and gait in post stroke subjects.
METHODS: Quasi experimental study design, in this study, A total of 76 subjects were assessed. 4 subjects were excluded out of which 72 eligible participants were randomly allocated into two groups. The subjects in Group A (n = 36) received Goal oriented dual task training and Group B (n = 36) received Proprioceptive neuromuscular facilitation. Subjects received intervention 5 days a week for 6 weeks. The BBS and TUG were used to assess the intervention effectiveness.
RESULTS: Statistical analysis revealed that baseline values were similar between the groups ($p>0.05$). Post-intervention results demonstrated that Group A achieved a higher mean Berg Balance Scale score (48.1 ± 1.53) compared with Group B (41.26 ± 2.37). Similarly, Group A showed a lower mean Timed Up and Go score (14.06 ± 1.50) than Group B (18.03 ± 3.38). These differences were statistically significant ($p=0.001$), indicating greater improvement in balance and functional mobility in Group A compared with Group B.
CONCLUSION: Both interventions resulted in significant improvements in balance and gait among individuals with stroke; however, goal-oriented dual-task training combined with conventional physiotherapy demonstrated superior efficacy compared with PNF-based rehabilitation.

Keywords: *Post stroke, balance, gait, goal oriented dual task training, neuroplasticity,* *Proprioceptive neuromuscular facilitation, Conventional Physiotherapy, BBS, TUG.*

INTRODUCTION

A stroke, once described by Hippocrates as a sudden episode of paralysis, is now recognized as a medical emergency involving a rapid loss of brain function due to an interruption in its blood supply. The World Health Organization defines it as the sudden appearance of neurological symptoms that persist for over 24 hours or lead to death, with the underlying cause being vascular.[1]

The term cerebrovascular accident (CVA) refers to this acute condition, which arises when blood flow to a part of the brain is either obstructed, commonly due to a clot or embolus, or compromised by bleeding from a ruptured vessel. As a result, the affected brain tissue is deprived of oxygen and essential nutrients, potentially leading to impairments such as weakness or paralysis on one side of the body, difficulty with speech or comprehension, or partial loss of vision, depending on the specific brain region involved.[2]

With the ageing population rising globally, the World Health Organization reported that the number of older adults worldwide had reached approximately 727 million by 2020, and this figure is expected to grow to over 1.5 billion by 2050.[3] In India, the burden of stroke continues to increase, with prevalence rates reported between 45 and 487 per 100,000 individuals and incidence rates ranging from 33 to 123 per 100,000, depending on urban or rural settings. Motor impairments are among the most common consequences following a stroke, affecting nearly 70% of survivors, as highlighted by the WHO.[4] Hemiparesis remains a leading concern in post-stroke rehabilitation due to its profound impact on postural control, locomotion, and the mechanics of gait, thereby limiting the individual's ability to perform daily functional activities.[5]

Balance refers to the ability to maintain the body's centre of mass (COM) within its base of support (BOS), ensuring postural stability during both static and dynamic activities. Impairments in balance may result from dysfunctions in the proprioceptive and sensory systems or from weakness in the trunk or limb muscles. Specifically, reduced activation of the trunk muscles can limit pelvic movement, cause trunk asymmetry, and hinder the body's ability to apply effective postural strategies. These factors collectively increase the risk of balance loss and falls.[6]

After a stroke, many individuals experience long-term difficulties with walking, often due to issues like muscle imbalances and weakness. These challenges in mobility can stem from altered developmental patterns that affect both sensory and motor functions, as well as disruptions in the brain's ability to control movement. Common walking impairments include irregularities during the swing and stance phases, slower walking speeds, increased time spent walking, and reductions in step and stride lengths.[7]

Research has highlighted that between 16.7% and 83% of stroke survivors experience balance-related issues, with over 80% facing persistent walking difficulties. Studies have also found that 50-70% of those who return home, to rehabilitation centres, or the hospital are at risk of falling due to ongoing impairments in balance and mobility.[8]

This leads to a significant reduction in their ability to carry out everyday tasks and independence. A key goal in the rehabilitation of stroke survivors is to restore balance and improve walking function, with physiotherapy being integral in enhancing independence and minimizing long-term disability for those recovering from a stroke.[9]

Conventional rehabilitation plays an important role in improving trunk mobility and enhancing muscle coordination, postural control, and overall movement in individuals recovering from a stroke. Techniques commonly used in this approach include active mobilization, muscle strengthening and task-specific exercises.

These methods help improve trunk muscle control, stability, balance, and functional mobility. The rehabilitation process often involves a combination of reflexive, synergistic, and out-of-synergy movements of the affected limbs, along with practical tasks such as transitioning from sitting to standing, stepping, reaching, and walking laterally and in a straight line, as supported by findings from relevant studies.[10]

Proprioceptive neuromuscular facilitation (PNF) is one of the rehabilitation approaches used nowadays in physical therapy. In PNF, the desired movement is repeated and again, the task is specified, and excessive mimicking of the activities of daily living ADL'S are used. Proprioceptive neuromuscular facilitation stands out as a rehabilitation method uniquely designed to benefit stroke survivors.[11]

It is based on stimulation of proprioceptive impulses by use of specific movement patterns, stretching, and use of increased resistance, including irradiation, which has been shown to produce greater reflex feedback to trunk muscles, causing enhancement of its other muscles in the body to play a significant role in maintaining the balance and gait. Hence, by stimulating proprioceptors, PNF enhances neuromuscular responses, playing a crucial role in the recovery of motor function.[12]

Goal-oriented dual task exercises positive impact on the recovery of stroke. It is a specialized rehabilitative approach that gets patients to concentrate on specific movements on position-based objectives by making them focus on achieving specific actions or position-based goals. This training method can be divided into cognitive, motor, and dual task training, in which a basic task and another task involving cognitive or motor interference are performed simultaneously.[13]

Dual task affects the gait and balance mechanism related to neuroplasticity, along with the activation of the brain regions that are associated with the central executive function. It promotes endogenous neural repair mechanisms, increases the number of synapses in the cerebral cortex, promotes the branching of axons and dendrites, and improves the ability of the nervous system to control the body, thus improving the gait and balance function of subjects.[14]

Most activities of daily living (ADLs) in human life require the simultaneous combination of motor tasks and cognitive functions while maintaining postural control, standing up, or walking. After a stroke, these abilities become impaired; therefore, dual-task activities can be regained through specific rehabilitation training. It is important to establish an effective rehabilitation strategy that improves balance, enhances gait outcomes, and prevents falls.[15]

PNF integration patterns stimulate proprioceptors within the muscles and tendons to enhance performance, flexibility, and balance. This approach is generally effective in maintaining responsiveness of the neuromuscular system by increasing coordination, which responds to the stimulation of muscular flexibility and strength.[16] Goal-oriented dual-task training contributes to restoring automatic balance control by influencing the reorganization process of the central nervous system (CNS) to postural stability.[17]

Although both goal-oriented dual-task training and proprioceptive neuromuscular facilitation (PNF) have been proven to enhance balance and gait independently, their combined effects in stroke rehabilitation remain underexplored. Stroke survivors commonly struggle with persistent gait and balance deficits, which greatly limit their functional independence and quality of life. Therefore, this study aims to investigate the potential benefits of integrating goal-oriented dual-task training with PNF to determine whether this combined approach can produce greater improvements in balance and gait among post-stroke individuals.

MATERIALS & METHODS

This is a quasi-experimental study design approved by the Ethical Committee of GSL

Medical College and General Hospital. The study was conducted for period of 1 year, from July 1st 2024 to June 30th 2025 at department of physiotherapy, tertiary care teaching hospital affiliated to Dr. NTR university. A total of 76 subjects aged 18–80 years with a clinical diagnosis of post-stroke balance and gait impairment were assessed. 4 subjects were excluded out of which 72 eligible participants were randomly allocated through systematic random sampling into two groups. The subjects in Group A (n = 36) received Goal oriented dual task training plus conventional physiotherapy and Group B (n =36) received Proprioceptive neuromuscular facilitation plus conventional physiotherapy. Intervention was given to participants 5 days a week for 6 weeks. The BBS and TUG were used to assess the intervention effectiveness.

Inclusion criteria: Both male and female subjects aged 18–80 years with a duration of stroke of less than three months, mini mental status examination of 24 OR >24, subjects with moderate berg balance score of 21-40, subjects with timed up and go tests of >15 seconds, subjects who gave consent to this study were included.

Exclusion criteria: Subjects who had orthopaedic injuries that could interfere with walking (e.g. fractures), visual and auditory impairments. other neurological disorders were excluded.

OUTCOME MEASURES

Pre-test and post-test measures were taken by using BBS and TUG.

BERG BALANCE SCALE (BBS) used to evaluate the static and dynamic aspects of balance and risk of falls in post stroke, which is a 14-item scale with scores 0-4 that requires 10-20 minutes time, The total score is 56 higher the score represents good balance lower the score represents balance impairment.[18]

TIMED UP AND GO TEST (TUG) used to evaluate the function of balance and mobility and fall risk, which is performance-based measure, lesser the time represents normal and higher the score represent impairment in balance and gait.[19]

INTERVENTION

GROUP A: GOAL ORIENTED DUAL TASK TRAINING:[20] (fig. 1)

The subjects in Group A followed a neurological rehabilitation program that included isometric exercises, concentric and eccentric exercises for the upper and lower limbs, core strengthening exercises, and Swiss ball, balance, and gait training exercises for the affected upper and lower limbs in the rehabilitation unit.

Additionally, the subjects in Group A received goal-oriented dual task training for the upper and lower limb of the paretic side. The goal-oriented dual task exercises were given in two ways:

- Motor Dual Task
- Cognitive Dual Task

1. Motor Dual Task Training

Motor dual task exercise was conducted for 40 minutes, including activities such as:

Slowly walking backwards, sideways, and forward on a smooth surface while holding a 100-gram sandbag. Exchanging a ball with a basket and bouncing a ball on the floor. Holding a bottle with water and walking. Exercises performed during walking such as holding a ball, holding a 200 ml cup of water, and walking forward, sideways, and backward, and transferring coins from one pocket to another. Walking with buttoning tasks, rising from a chair, and picking up plastic cups. The exercises lasted for 45 minutes.

2. Cognitive Dual Task Training

Cognitive dual task with walking program included:

Matching words with colours, naming opposite words, letter-number sequencing, calculating time, backward numbers. In this cognitive dual-task training, subjects performed balance and cognitive exercises using traffic light signals a familiar concept. The task involved:

Using visual cues displayed on a monitor and elastic bands to adjust resistance and difficulty. While standing, the subject moved their less-affected leg in three hip flexion directions based on randomly changing red and green signals on the screen. Green indicated “go,” prompting movement within 5 seconds, while red meant “stop.” Each of the three directions was linked to a specific signal, and the subject had to return the leg to the start position within another 5 seconds.

DUAL-TASK GAIT REHABILITATION (DTGR) PROGRAM:

The DTGR program is designed to integrate both motor and cognitive tasks in a progressively challenging manner, with each subsequent week increasing the complexity to enhance subject’s ability to perform dual tasks effectively.

Initial Phase:[21]

Began with relatively simple cognitive activities such as:

Counting backward by ones. Subjects also engage in light motor activities such as walking while holding a half-filled glass of water in their non-affected hand. These tasks are carried out under low-demand motor conditions, such as walking on flat ground or along designated walking paths. The motor challenge is slightly increased by having the subject carry a glass filled to 75% with water, again using the non-affected hand.

Progressive Phase:[22]

Cognitive load was further expanded by adding semantic fluency tasks, e.g., naming types of birds, towns, or colours, while walking. Visual scanning tasks were introduced, requiring subjects to search for specific objects, images, or words presented on the side of their unaffected limb. Motor difficulty began to advance as well: Tasks progressed from basic comfortable walking to walking while carrying light weights (100–250 grams), and then to walking along a narrow line, demanding greater balance and control.

Intermediate Phase:[17]

Later both motor and cognitive tasks became more complex.

Motor component introduces moderate challenges such as:

Walking with light to moderate weights (250–500 grams). Stepping over small obstacles (<5 cm in height), encouraging adjustment of walking pattern and posture. Walking while holding a half-full glass of water in the affected (paretic) hand, enhancing motor control and confidence. Cognitive component progresses to alternating semantic fluency tasks which include naming animals and fruits (D1), fruits and vegetables (D2), fruits and supermarket items (D3). These tasks demand greater executive function and mental flexibility. The visual scanning task is adjusted and subjects identified targets on their paretic side, requiring increased attentional shifting and visuospatial awareness.

Final Phase:[23]

In the final phase, the tasks reach their highest complexity.

Motor tasks included:

Fast-paced walking, walking with added weights (100–250 g or 250–500 g), stepping over obstacles up to 10 cm in height, walking while holding a glass filled to 75% with water in the paretic hand, requiring high levels of upper limb stability and coordination.

Cognitive tasks involved highly complex alternating semantic fluency activities, such as switching between:[24]

Types of fish and birds, fruits and town names, or colours and furniture. The visual scanning task now requires the participant to locate targets not only in their lateral visual field but also behind them, adding a further challenge to postural control and spatial orientation.

Environmental Modulation and Duration:[25]

Throughout the training, the level of cognitive difficulty is modulated by environmental conditions. Initially, tasks are performed in a quiet environment to minimize distractions. As subjects progress, music selected by the individual is introduced to simulate real-life auditory distractions. Later, news radio is added, presenting complex, unpredictable auditory stimuli.

Treatment duration was 45 minutes twice a day for 6 weeks.

FIG. 1: GROUP – A GOAL ORIENTED DUAL TASK TRAINING

a. Cognitive Dual Task: Red Colour Stop, b. Cognitive Dual Task: Green colour Go, c. Motor Dual Task: Bottle Water, Sand Bag, d. Cognitive Dual Task: Bottle Water, Obstacle, e. Cognitive Dual Task: Fruit Identification and Walking, f. Cognitive Dual Task: Fruit Identification and Walking.

GROUP B: PROPRIOCEPTIVE NEUROMUSCULAR FACILITATION:

The treatment techniques in proprioceptive neuromuscular facilitation were PNF neck pattern; chopping and lifting; pelvic PNF and trunk PNF to the paretic side of the subject.

PNF NECK MOVEMENT USING A COMBINATION OF ISOTONIC TECHNIQUE:[26] **(fig.2)**

Combination of isotonic technique – combined concentric eccentric and stabilizing contractions of one group of muscles without relaxation.

The therapist resisted the subject's moving actively through a desired ROM (concentric contraction). At the end of the range of motion, the therapist instructed the subject to stay in that position (stabilizing contraction). Once stability was attained, the therapist instructed the patient to allow the part to be moved slowly back to the starting position (eccentric contraction). There is no relaxation between the different types of muscle activities. Each pattern =10 times 3sets.

Neck movement pattern consists of:

1. EXTENSION/ RIGHT LATERAL FLEXION/RIGHT ROTATION-

- Subject position-Sitting
- Therapist position –Stand behind subject at the right side.
- Grips – The therapist placed the right thumb at the center of the subject's chin and positioned the left hand on top of the subject's head. Resistance was then applied with the right hand over the chin.

2. EXTENSION/LEFT LATERAL FLEXION/LEFT ROTATION-

- Subject position –Sitting
- Therapist position-Stand behind the subject.
- Grips –The therapist placed the left thumb at the center of the subject's chin and positioned the right hand on top of the patient's head. Resistance was applied using the left hand.

3. FLEXION/LEFT LATERAL FLEXION/LEFT ROTATION-

- Subject position –sitting
- Therapist position-Stand behind the subject
- Grip –The therapist had positioned the fingertips of the right hand beneath the subject's chin, placed the left hand on top of the head, and provided resistance with the right hand.

4. FLEXION /RIGHT LATERAL FLEXION/RIGHT ROTATION-

- Subject position – Sitting
- Therapist position-Stand behind the subject
- Grip –The therapist had positioned the fingertips of the left hand beneath the subject's chin, placed the right hand on top of the head, and provided resistance with the left hand.

FIG. 2: NECK PNF

TRUNK PROPRIOCEPTIVE NEUROMUSCULAR FACILITATION: [10,27] **(fig.3)**

CHOPPING PATTERN:

Subject position -Supine lying

Therapist position - Stand beside the subject

Starting position -Extend subjects arms overhead and interlock your fingers, forming a stable grip and keep head in a neutral position, looking straight up.

Chop Motion with Trunk and Neck Movement - The subject's arms were moved diagonally downward to one side (for example, toward the right hip) as if making a chopping motion, and the shoulders and trunk followed the movement.

Neck Movement - As the subject's arms moved, the head was turned toward the chopping side, bringing the chin closer to the shoulder (for example, the head was turned to the right while chopping to the right).

LIFTING PATTERN:

Subject position -Supine lying

Therapist position - Stand beside the subject.

Starting position -Extend subjects arms down towards right side of the hip, interlocking your fingers.

Lift Motion with Trunk and Neck Movement - The subject's arms were moved diagonally upward toward the left, as if lifting, and the shoulders and trunk followed the movement.

Neck Movement - As the subject's arms moved, the head was turned toward the lifting side, bringing the chin closer to the shoulder (for example, the head was turned to the left while lifting to the left), and then the movement was repeated on the right side.

FIG. 3: TRUNK PNF; Chopping and Lifting Pattern

PELVIC PNF:[11] (fig.4,5)

Rhythmic initiation, slow reversal (dynamic reversal), and stabilizing reversal were administered for 15 minutes, six days a week, over a period of four weeks. The treatments were carried out on the afflicted side, with the hips positioned in 100° of flexion and the knees in 45° of flexion. These interventions were applied to facilitate anterior pelvic elevation and posterior pelvic depression.

Rhythmic initiation was commenced once the subject had voluntarily relaxed. The therapist first performed passive movement, and then progressed to assisted movement, followed by active movement, and finally active-resisted movement.

Slow reversal involved a dynamic concentric contraction of the strong agonists, which was immediately followed by a dynamic concentric contraction of the weak antagonists.

Stabilizing reversal was a technique that involved alternating isotonic contractions with sufficient resistance to prevent body movement. The therapist permitted only minimal movement in response to the dynamic command.

FOR ANTERIOR ELEVATION:

- Subject position – side lying.

- Therapist position-stand behind the subject.
- Grip –The therapist's hands were placed on the subject's anterior crest of the ilium, and the command "pull up" was used to facilitate pelvic anterior elevation.

FOR POSTERIOR DEPRESSION:

- Subject position – side lying.
- Therapist position-stand behind the subject.
- Grip –The therapist's hands were placed on the subject's ischial tuberosity, and the command "pull down" was used to facilitate pelvic posterior depression.

FOR ANTERIOR DEPRESSION:

- Subject position – side lying.
- Therapist position-stand in front of the subject.
- Grip –The therapist's hands were placed on the subject's anterior crest of the ilium, and the command "pull down and forward" was used to facilitate pelvic anterior depression.

FOR POSTERIOR ELEVATION:

- Subject position – side lying.
- Therapist position-stand behind the subject.
- Grip –The therapist's hands were placed on the subject's ischial tuberosity, and the command "press up into the therapist's hand" was used to facilitate pelvic posterior elevation.

FIG. 4: PELVIC PNF; Anterior Elevation and Depression

FIG. 5: PELVIC PNF; Posterior Elevation and Depression

CONVENTIONAL REHABILITATION PROGRAM:[28]

Balance training exercises: Body weight propulsion of body in intended position they are single leg stance, footsteps to step, narrow step stance, tandem stance, heel raises.

Strengthening exercises: Isometric exercises, concentric and eccentric exercises for upper limb and lower limbs, core strengthening exercises: Pelvic bridging, trunk rotation, abdominal curl up's, forward reach, and lateral reach.

Gait training exercises: Marching in place, terminal knee extension with March, hurdle step over, sidestep over, backwards walking.

Conventional physiotherapy total duration is 45 minutes.

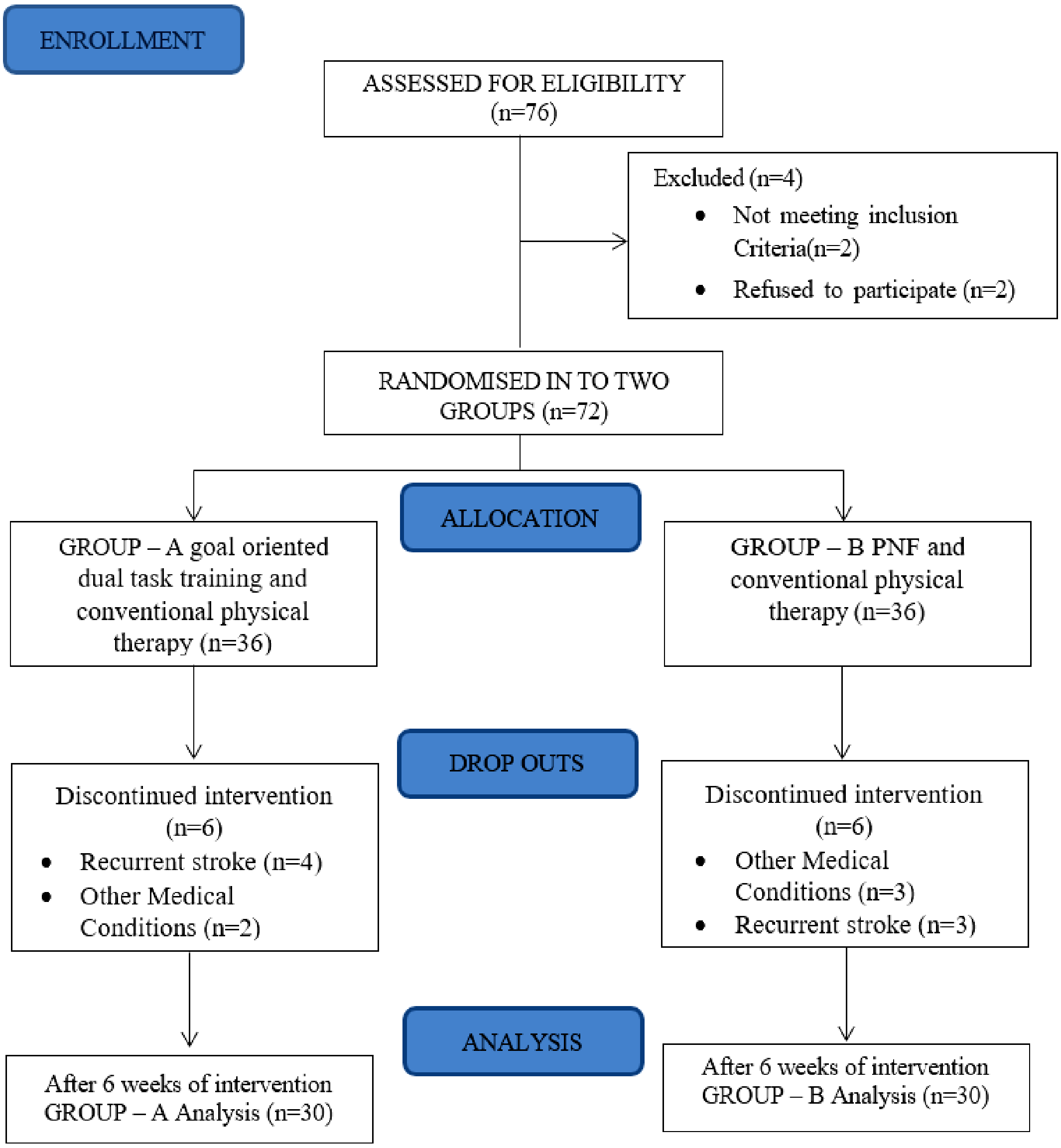

FIG. 6: CONSORT FLOW CHART OF STUDY PARTICIPANTS FROM ENROLLMENT TO ANALYSIS

Statistical Analysis

All statistical analysis was done by using SPSS software version 20.0 and MS excel 2019. All descriptive data was presented as mean ± standard deviation and mean difference were calculated and presented. Paired student "t" test was performed to assess the statistical difference within the groups for Berg balance scale for balance and timed up and go test for gait function. Independent student "t" test was performed to assess the statistically significant difference in mean value between the groups for Berg balance scale for balance and timed up and go test for gait function. Data was tabulated and graphically represented. For all statistical analysis p<0.05 was considered as statistically significant.

RESULT

The results of the study were analysed in terms of Berg balance scale for balance and timed up and go test. The consort flowchart of the study showed the study organization in terms of subject's enrollment, screening, allocation, and analysis following intervention as shown in figure 6.

A total of 76 subjects were screened for eligibility, among which 72 subjects were included in the study trial. All the 72 subjects underwent baseline assessment and were randomized into two groups consisting of 36 subjects in each group respectively. At the time of intervention period, 6 subjects from Group A discontinued due to recurrent stroke (n=4) and other medical conditions (n=2), and 6 subjects from Group B discontinued due to recurrent stroke (n=3) and other medical conditions (n=3). Therefore, a total of 30 subjects in Group A and 30 subjects in Group B completed the study. At a significance level set at p ≤ 0.05, both the groups demonstrated statistically significant improvements in BBS and TUG.

TABLE 1: COMPARISON OF MEAN SCORES OF BERG BALANCE SCALE BETWEEN THE GROUPS: [PRE – TEST]

BBS		**MEAN**	**STANDARD DEVIATION**	**P VALUE**	**INFERENCES**
PRE TEST	GROUP A	33.06	2.58	0.883	INSIGNIFICANT
	GROUP B	32.96	2.37		

RESULTS: The above table 1 indicate that the PRE-TEST mean scores of the BERG BALANCE SCALE between the two groups were found to be statistically insignificant (p<0.05). Group A had a PRE - TEST mean score of 33.06, while Group B had a PRE-TEST mean score of 32.96 indicating an insignificant difference of PRE-TEST values between groups A and B.

TABLE 2: COMPARISON OF MEAN SCORES OF BERG BALANCE SCALE BETWEEN THE GROUPS: [POST – TEST]

BBS		**MEAN**	**STANDARD DEVIATION**	**P VALUE**	**INFERENCES**
POST TEST	GROUP A	48.1	1.53	0.001	HIGHLY SIGNIFICANT
	GROUP B	41.26	2.37		

RESULTS: The above table 2 indicate that the POST-TEST mean scores of the BERG BALANCE SCALE between the two groups were found to be statistically highly significant (p<0.05). Group A had a POST-TEST mean score of 48.1, while Group B had a POST-TEST mean score of 41.26 indicating statistically significant difference of POST-TEST values between groups A and B.

TABLE 3: COMPARISON OF MEAN SCORES OF TIMED UP AND GO TEST BETWEEN THE GROUPS: [PRE – TEST]

BBS		**MEAN**	**STANDARD DEVIATION**	**P VALUE**	**INFERENCES**
PRE TEST	GROUP A	23.30	2.73	0.924	INSIGNIFICANT
	GROUP B	23.1	2.66		

RESULTS: The above table 3 indicate that the PRE-TEST mean scores of the TIMED UP AND GO TEST between the two groups were found to be statistically insignificant (p<0.05). Group A had a PRE -TEST mean score of 23.30, while Group B had a PRE-

TEST mean score of 23.1 indicating an insignificant difference of PRE-TEST values between groups A and B.

TABLE 4: COMPARISON OF MEAN SCORES OF TIMED UP AND GO TEST BETWEEN THE GROUPS: [POST – TEST]

BBS		MEAN	STANDARD DEVIATION	P VALUE	INFERENCES
POST TEST	GROUP A	14.06	1.50	0.001	HIGHLY SIGNIFICANT
	GROUP B	18.03	3.38		

RESULTS: The above table 4 indicate that the POST-TEST mean scores of the TIMED UP AND GO TEST between the two groups were found to be statistically highly significant (p<0.05). Group A had a POST-TEST mean score of 14.06, while Group B had a POST-TEST mean score of 18.03 indicating statistically significant difference of POST-TEST values between groups A and B.

DISCUSSION

The present study aimed to assess the effectiveness of Goal-Oriented Dual Task Training combined with Proprioceptive Neuromuscular Facilitation (PNF) on balance and gait in post-stroke subjects, using the Timed Up and Go Test (TUG) and Berg Balance Scale (BBS) as outcome measures. The results indicated that this combined approach effectively enhanced balance and gait autonomy in stroke patients. While previous studies have shown the individual benefits of PNF and Goal-Oriented Dual Task Training, limited research has compared their combined effects, leading to existing uncertainties. The present findings provide supportive evidence for their synergistic role in improving functional mobility and postural control in post-stroke rehabilitation.

In Group A (Goal-Oriented Dual Task Training), participants showed statistically significant improvements in both the Berg Balance Scale (BBS) (P = 0.001) and Timed Up and Go (TUG) test (P = 0.001). These results are reinforced by Sarulatha H et al., who observed that dual-task activities enhance balance and reduce postural sway by improving postural stability. The authors explained that this improvement arises from the ability to shift attention from internal focus; such as muscle activation and joint movement to an external focus on the movement goal or target activity, enabling participants to control posture more efficiently and perform movements with greater ease.[29]

Similarly, Sweety Subha P. et al. compared single-task and dual-task training on functional mobility in post-stroke patients and reported that dual-task practice, which requires simultaneous performance of cognitive and motor tasks, produced greater benefits than single-task interventions. Their findings indicated that this approach helps patients divide attention, coordinate movements efficiently, and promotes automatization of motor tasks, resulting in smoother and less effortful movements. Consequently, participants demonstrated faster improvements in processing speed, balance, and gait, supporting that dual-task training enhances motor learning through neuroplastic mechanisms and better prepares stroke survivors for daily functional challenges.[30] collectively, these studies complement our observations, suggesting that goal-oriented dual-task interventions are highly effective in improving balance, gait, and overall functional mobility in post-stroke rehabilitation.

Lu Zhang et al. demonstrated through a randomized controlled trial that cognitive–motor dual-task training stimulates neuroplasticity, enhances synaptogenesis, and activates brain regions such as the prefrontal cortex, thereby improving neuronal communication, neural repair, and the brain's control over movement and posture.[22] Similarly, Sophie Tassel

Ponnche et al. emphasized that a personalized dual-task rehabilitation program, which engaged cognitive functions like decision-making, attention shifting, and planning alongside motor tasks including postural adjustments and spatial awareness, significantly enhanced gait stability and balance, reflecting the added value of training mind and body together.[31]

Xyeyi Zhang, in a meta-analysis, explained that dual-task interventions promote synapse formation in the cerebral cortex, encourage axonal and dendritic branching, and strengthen the nervous system's ability to regulate posture and movement, supporting functional recovery after stroke.[13] In line with these findings, Weiyuan Tao et al. highlighted that dual-task training improves gait efficiency, automatizes walking, and enhances sensorimotor integration by optimizing visual, vestibular, and proprioceptive inputs.[24] Collectively, these studies complement our observations, as we also noted that integrating cognitive and motor tasks in rehabilitation leads to significant improvements in balance, gait performance, and overall functional adaptability in post-stroke patients.

In Group B, participants receiving traditional Proprioceptive Neuromuscular Facilitation (PNF) therapy showed significant improvements in TUG (P = 0.001) and BBS (P = 0.001). Moon S-J and Han S-Y et al. observed in their randomized controlled trial that PNF exercises targeting the neck, pelvis, and trunk facilitate core muscle activation and coordination, primarily improving lateral stability and enhancing both static and dynamic balance.[32] These improvements were reflected in gains on the BBS and TUG, which aligns with our findings that PNF-based interventions effectively enhance trunk control, balance, and overall functional mobility in post-stroke rehabilitation.

Shantanu Sharma et al. (2025) explained that lower limb PNF in stroke patients stimulates proprioceptors and enhances neuromuscular responses, with movement patterns that mimic natural human motion. This approach engages multiple muscle groups in a coordinated manner, supporting improvements in gait, balance, and postural control.[33] Similarly, Smit R. Shah et al. (2021), in their systematic review, observed that pelvic PNF emphasizes proximal-to-distal motion control, particularly through anterior elevation and posterior depression patterns during gait swing. The authors reported that this resistance-based PNF facilitates motor responses, reinforces motor learning, and improves pelvic stability, which indirectly enhances gait and balance in stroke patients.[34] These findings reflect our results, indicating that lower limb and pelvic PNF interventions effectively promote coordinated movement, postural control, and functional recovery in post-stroke rehabilitation.

Shin Junn Park et al. (2020) explained that diagonal pattern training, using chopping and lifting techniques, improves trunk function, balance, and gait in stroke patients. These movements involve separate diagonal rotations of the thorax and pelvis, targeting both anteroposterior and medio lateral trunk control, which stroke patients often struggle to achieve. The authors observed that enhancing trunk coordination and motion through these patterns positively influenced gait speed, as trunk control is closely linked to walking efficiency.[35] These findings are in line with our results, suggesting that diagonal pattern training effectively improves trunk mobility, coordination, and gait performance in post-stroke rehabilitation.

In addition to dual-task and PNF interventions, conventional physiotherapy- this includes stretching, strengthening, balance and coordination exercises, and gait training; also contributes significantly to functional recovery. Stretching restores normal muscle length and joint mobility, facilitating smoother movements, while strengthening exercises enhance muscle strength and joint stability, especially in the lower limbs, improving postural control and gait propulsion.

Balance and coordination exercises promote sensory–motor integration, proprioceptive feedback, and interlimb coordination, helping patients maintain stability during standing and walking. Gait training further reinforces these improvements through repetitive, task-specific practice, encouraging neuroplasticity, rhythmic stepping, and symmetrical weight shifting.[15] Collectively, these interventions improve neuromuscular activation, postural stability, and movement efficiency, leading to better balance, faster gait, and greater independence in post-stroke rehabilitation.

The findings of the present study revealed that both Goal-Oriented Dual Task Training and Proprioceptive Neuromuscular Facilitation (PNF) showed significant improvements in balance and gait among post-stroke individuals. However, participants in the Goal-Oriented Dual Task Training group demonstrated greater improvement in functional performance and mobility outcomes compared to those who received PNF-based interventions. This indicates that incorporating goal-directed activities that involve simultaneous motor and cognitive components may lead to superior recovery of balance and walking ability in stroke rehabilitation.

The study findings indicate that after 6 weeks of interventions, Goal-Oriented Dual Task training and PNF were effective in improving balance and gait in post-stroke patients. The results demonstrated that Goal-Oriented Dual Task training showed greater improvement in balance and gait compared to PNF. Thus, this study concludes that Goal-Oriented Dual Task training is a valuable intervention for enhancing balance and gait, alongside conventional rehabilitation.

However, the study has its limitations including a small sample size, lack of evaluator blinding, and absence of follow-up assessment. Additionally, it is recommended that future studies include longer study durations with follow-up periods to assess long-term benefits and consider larger sample sizes to improve the generalizability of findings.

CONCLUSION

The present study concludes that both goal-oriented dual-task training with conventional physiotherapy and proprioceptive neuromuscular facilitation with conventional physiotherapy significantly improve balance and gait in stroke patients. However, goal-oriented dual-task training demonstrates greater effectiveness and is therefore recommended as an adjunct to PNF with conventional physiotherapy for optimizing balance and gait rehabilitation in stroke.

Declaration by Authors

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