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EFFECT OF BALANCE TRAINING WITH MOTOR IMAGERY TRAINING ON BALANCE AND GAIT VELOCITY IN SUBJECTS WITH SUB ACUTE STROKE

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ABSTRACT

Background: Stroke frequently results in impaired balance and gait, limiting functional mobility and independence. Although conventional balance training improves postural control, combining it with motor imagery training (MIT) may enhance motor learning and functional recovery. However, evidence regarding the combined intervention in individuals with subacute stroke remains limited.

Objective: To determine the effect of balance training combined with motor imagery training on balance and gait velocity in individuals with subacute stroke, compared with balance training alone.

Methods: A randomized experimental study was conducted involving 30 individuals with subacute stroke, allocated into an experimental group (n = 15) and a control group (n = 15). The experimental group received motor imagery training for 15–20 minutes followed by 30 minutes of balance training, whereas the control group received 45 minutes of balance training alone. Both groups underwent intervention for six weeks, five sessions per week. Balance and walking performance were assessed before and after the intervention using the Berg Balance Scale (BBS) and 10-Meter Walk Test (10MWT), respectively. Gait velocity was also evaluated. Statistical analysis was performed using SPSS, with paired and independent t-tests and a significance level of $p < 0.05$.

Results: Both groups demonstrated statistically significant improvements in all outcome measures following the intervention ($p < 0.001$). Post-intervention BBS scores were significantly higher in the experimental group than in the control group (40.40 ± 2.80 vs. 35.00 ± 2.74; $p < 0.001$). Gait velocity was also significantly higher in the experimental group (0.318 ± 0.053 m/s vs. 0.265 ± 0.046 m/s; $p = 0.046$). Although the experimental group demonstrated a lower 10MWT completion time than the control group (32.87 ± 8.11 s vs. 38.13 ± 7.52 s), the between-group difference was not statistically significant ($p = 0.060$).

Conclusion: Balance training combined with motor imagery training produced greater improvements in balance and gait velocity than balance training alone in individuals with subacute stroke. However, the between-group difference in 10MWT completion time was not statistically significant. Motor imagery training may be considered an adjunct to conventional balance rehabilitation for improving functional outcomes following stroke.

Keywords: Subacute stroke; Motor imagery training; Balance training; Berg Balance Scale; 10-Meter Walk Test; Gait velocity.

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INTRODUCTION

Stroke is a major neurological disorder and a leading cause of mortality and long-term disability worldwide. It occurs due to an interruption of cerebral blood flow resulting from ischemic or hemorrhagic events, leading to neuronal injury and impairments in motor, sensory, cognitive, and functional abilities [1,2]. Despite advances in acute management and rehabilitation, many stroke survivors continue to experience functional limitations that affect their independence and quality of life.

Among the common consequences of stroke, balance impairment and gait dysfunction are major contributors to reduced mobility and functional independence. Post-stroke gait abnormalities may include reduced walking speed, gait asymmetry, decreased stride length, and impaired movement coordination. Similarly, impaired postural control can affect weight shifting, stability during standing and walking, and the ability to perform daily activities safely. These deficits may increase the risk of falls and restrict participation in community activities. Therefore, improving balance and walking performance is an important goal of stroke rehabilitation [3,4].

Balance training is a fundamental component of physiotherapy for individuals with stroke. It involves structured exercises designed to improve postural stability, weight shifting, coordination, and functional mobility through repetitive and task-oriented practice. Although conventional balance training can improve postural control and functional performance, recovery may remain incomplete in some individuals.

Motor imagery training (MIT) is a cognitive rehabilitation approach involving the mental rehearsal of movements without their actual physical execution. Motor imagery engages neural networks involved in movement planning and execution and may support motor learning and neuroplasticity [5]. It can provide additional opportunities for movement practice and may complement physical rehabilitation, particularly when combined with task-specific exercises. Integrating MIT with balance training may therefore offer a combined approach that addresses both movement-related neural processes and physical postural performance.

Previous research has investigated motor imagery training for improving motor function, balance, and gait performance following stroke. However, differences in intervention protocols, treatment duration, and outcome measures limit comparisons across studies. Furthermore, the available evidence regarding the combined effects of structured motor imagery training and balance training on both balance and gait velocity in individuals with subacute stroke remains limited [6–8].

Therefore, the present study aimed to determine the effect of balance training combined with motor imagery training on balance and gait velocity in individuals with subacute stroke, compared with balance training alone. Balance was assessed using the Berg Balance Scale (BBS), while walking performance was evaluated using the 10-Meter Walk Test (10MWT) and gait velocity.

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MATERIALS AND METHODS

Study Design and Setting

A randomized controlled trial was conducted among individuals with subacute stroke at the Neurology Ward of Sri Venkateswara Institute of Medical Sciences (SVIMS) Hospital and the College of Physiotherapy, SVIMS, Tirupati, Andhra Pradesh, India. The overall study duration was six months, and the intervention period was six weeks.

Sample Size and Sampling Method

A total of 30 individuals with subacute stroke who fulfilled the eligibility criteria were recruited using purposive sampling. Participants were allocated into two groups using the lottery method, with 15 participants in each group. The experimental group received motor imagery training combined with balance training, whereas the control group received balance training alone.

Eligibility Criteria

Inclusion Criteria

- Age between 20 and 55 years.
- Clinical history of ischemic or hemorrhagic stroke.
- Ability to stand and maintain standing balance, with a Berg Balance Scale (BBS) score of 24 or higher.
- Adequate cognitive function with Mini-Mental State Examination (MMSE) score of 22 or higher.
- Ability to walk independently over 10 metres, with or without usual assistance.
- No previous gait-related training interventions.
- Male and female participants.

Exclusion Criteria

- Comorbidities or disabilities other than stroke, as specified in the study protocol.
- Balance impairments attributable to other conditions, such as Parkinson’s disease or vestibular disorders.
- Proprioceptive sensory impairment.
- Unstable medical conditions.
- Cognitive impairment, defined as an MMSE score below 22.
- Age above 55 years.

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Ethical Approval and Informed Consent

Ethical approval was obtained from the Institutional Ethics Committee of SVIMS, Tirupati (approval number: 1875; Roc. No. AS/11/IEC/SVIMS/2017). The trial registration number recorded in the thesis was CTRI/2026/01/102413. The study procedure was explained to the participants, and written informed consent was obtained before participation. The thesis also describes consent involving relatives when participants were unable to provide consent themselves.

Study Procedure and Intervention

Eligible participants underwent baseline assessment before the intervention. The experimental and control groups received their respective interventions for 45 minutes per session, five sessions per week, for six consecutive weeks. Post-intervention assessments were performed using the same outcome measures.

Experimental Group: Motor Imagery Training Combined with Balance Training

Participants in the experimental group received 15–20 minutes of motor imagery training, immediately followed by 30 minutes of conventional balance training.

Motor imagery training was conducted in a quiet, distraction-free environment. Participants were seated comfortably and guided through relaxation, deep diaphragmatic breathing, attention focusing, and movement imagery instructions. Cognitive ability and the capacity to imagine movements were assessed before training. Therapist demonstrations and visual cues presented using an Android tablet were used to support imagery practice.

Participants were instructed to use visual and kinesthetic motor imagery to mentally rehearse the balance tasks before performing them physically. Imagery tasks included static balance, dynamic balance, weight shifting, functional reaching, limits of stability, tandem walking, single-leg stance, multidirectional stepping, obstacle negotiation, perturbation-related activities, and functional tasks. Verbal instructions, demonstrations, and feedback were provided to facilitate accurate mental rehearsal.

Following motor imagery practice, participants performed the corresponding conventional balance exercises for 30 minutes.

Control Group: Conventional Balance Training Alone

Participants in the control group received 45 minutes of conventional balance training per session, five sessions per week, for six consecutive weeks. The programme included static and dynamic balance exercises, weight shifting, functional reaching, limits-of-stability activities, tandem standing and walking, single-leg stance, multidirectional stepping, obstacle negotiation, perturbation training, and functional balance tasks.

Exercise difficulty was progressed according to each participant’s performance, safety, and tolerance. Verbal cues, visual feedback, and manual correction were provided as required. Rest periods and close supervision were used to support safe performance.

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Outcome Measures

Berg Balance Scale

The Berg Balance Scale was used to assess balance performance. It is a clinical measure of functional balance comprising 14 tasks involving sitting, standing, transfers, reaching, turning, and other balance-related activities. The total score ranges from 0 to 56, with higher scores indicating better balance performance.

10-Meter Walk Test

The 10-Meter Walk Test was used to evaluate walking performance. Walking time over the test distance was recorded using a stopwatch. The test was administered before and after the intervention to assess changes in walking performance.

Gait Velocity

Gait velocity was evaluated in metres per second (m/s) using the 10-Meter Walk Test data, according to the study protocol. Higher gait velocity indicates faster walking performance.

Statistical Analysis

Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS). Descriptive statistics were used to summarize participant characteristics and outcome measures. Paired t-tests were used to compare pre-intervention and post-intervention scores within each group, while independent t-tests were used to compare outcomes between the experimental and control groups. The level of statistical significance was set at $p < 0.05$.

RESULTS

Both groups demonstrated improvements in balance and gait performance following six weeks of intervention. In the experimental group, the mean Berg Balance Scale (BBS) score increased from 26.66 ± 2.22 to 40.40 ± 2.19, while the mean 10-Meter Walk Test (10MWT) completion time decreased from 57.00 ± 9.92 seconds to 32.80 ± 7.43 seconds. Gait velocity increased from 0.17 ± 0.03 m/s to 0.31 ± 0.08 m/s. In the control group, the mean BBS score increased from 26.53 ± 2.19 to 35.00 ± 2.64, the mean 10MWT completion time decreased from 54.53 ± 11.40 seconds to 38.13 ± 7.25 seconds, and gait velocity increased from 0.18 ± 0.03 m/s to 0.26 ± 0.04 m/s. The thesis reports statistically significant pre- to post-intervention improvements in both groups.

Between-group comparison of post-intervention outcomes showed that the experimental group achieved a significantly higher BBS score than the control group (40.40 ± 2.80 versus 35.00 ± 2.74; $p < 0.001$). Gait velocity was also significantly higher in the experimental group than in the control group (0.318 ± 0.053 m/s versus 0.265 ± 0.046 m/s; $p = 0.046$). Although the experimental group demonstrated a lower mean 10MWT completion time than the control group (32.87 ± 8.11 seconds versus 38.13 ± 7.52 seconds), the difference was not statistically significant ($p = 0.060$).

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Table 1: Descriptive data of Experimental and Control group:

Variable	Experimental Group	Control group	P -value
AGEIN YEARS (Mean ±SD)	**47.93±3.69**	**49.20±4.43**	**0.402**
GENDER RATIO (M:F)	**7:8**	**8:7**	**1**
AFFECTEDSIDE RATIO (R:L)	**7:8**	**7:8**	**1**

Table 2: Within group analysis of Pre and post mean values of experimental group:

Outcome	Pre mean ± SD	Post Mean ± SD	Mean difference	T value	P value
BBS	26.66± 2.22	40.4± 2.19	13.74	-43.49	<0.001
10 MWT (sec)	57 ± 9.92	32.8 ±7.43	24.2	13.17	<0.001
Gait velocity(m/sec)	0.17 ± 0.03	0.31 ± 0.08	0.14	-16.73	<0.001

Table 3-Within group analysis of Pre and post mean values of control group:

OUTCOME	PRE MEAN ± SD	POST MEAN ± SD	MEAN DIFFERENCE	T VALUE	P VALUE
BBS	26.53± 2.19	35± 2.64	8.47	-11.71	<0.001
10 MWT (sec)	54.53 ± 11.4	38.13 ±7.25	-16.4	13.17	<0.001
Gaitvelocity(m/sec)	0.18 ± 0.03	0.26 ± 0.04	0.08	-16.73	<0.001

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Table 4: Comparison of post intervention mean of experimental and control groups

OUTCOME	Experimental group MEAN ± SD	Control group MEAN ± SD	Mean difference	T VALUE	P VALUE
BBS	40.40 ± 2.80	35 ± 2.74	5.40	6.081	<0.001
10 MWT(sec)	32.87 ± 8.11	38.13 ± 7.52	-5.26	-1.963	0.060
Gait velocity (m/sec)	0.318 ± 0.053	0.265 ± 0.046	0.053	2.093	0.046

DISCUSSION

The present randomized experimental study evaluated the effectiveness of motor imagery training combined with balance training on balance and gait velocity in individuals with subacute stroke, compared with balance training alone. The findings demonstrated improvements in balance and walking performance in both groups following six weeks of intervention. However, the experimental group showed a significantly higher post-intervention Berg Balance Scale (BBS) score and significantly greater gait velocity than the control group. In contrast, the between-group difference in 10-Meter Walk Test (10MWT) completion time was not statistically significant. These findings suggest that incorporating motor imagery training into conventional balance training may provide additional benefits for selected aspects of postural control and walking performance in individuals with subacute stroke.

The improvement in BBS scores observed in both groups may be attributed to the task-specific nature of the balance exercises. The intervention included static and dynamic balance activities, weight shifting, functional reaching, tandem stance and walking, single-leg stance, multidirectional stepping, and obstacle negotiation. These activities require participants to control their centre of mass within the base of support, adjust their posture during movement, and respond to changing environmental demands. Repeated practice of these tasks may improve postural control, movement coordination, and the ability to perform functional balance activities. The greater post-intervention BBS score in the experimental group suggests that adding motor imagery training may have enhanced the effects of physical balance practice.

The findings are consistent with the literature reviewed in the thesis regarding the combined use of motor imagery and physical rehabilitation after stroke. The studies attributed to Park et al. (2023) and Page et al. (2022) reported greater improvements in balance and gait-related outcomes when motor imagery was incorporated into rehabilitation compared with conventional rehabilitation alone [9,10]. The systematic review attributed to Braun et al. (2021) also described improvements in balance and functional mobility in studies combining motor imagery with conventional physiotherapy [11]. Although these findings broadly support the

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results of the present study, differences in participant characteristics, intervention duration, imagery protocols, and outcome measures should be considered when comparing the studies.

The improvement in gait velocity in both groups may be associated with repeated practice of functional movements, multidirectional stepping, weight transfer, and dynamic balance activities. Walking requires coordinated control of the trunk and lower limbs, adequate weight acceptance, postural stability, and the ability to transfer the centre of mass from one limb to the other. Balance training may help improve these components, thereby supporting more efficient walking. The significantly higher post-intervention gait velocity in the experimental group suggests that motor imagery may have provided an additional benefit when combined with physical practice.

A physiological explanation for the additional improvement observed in the experimental group is that motor imagery involves the mental rehearsal of movement without overt physical execution. During motor imagery, neural networks involved in motor planning and movement preparation, including the premotor cortex, supplementary motor area, and related sensorimotor regions, may be engaged [12]. Repeated mental rehearsal of balance and walking tasks may help reinforce movement representations and support motor learning. When followed by actual task performance, imagery may complement physical practice by allowing participants to mentally prepare for the movement, anticipate postural demands, and focus on the intended movement sequence. These mechanisms may have contributed to the greater improvements in balance and gait velocity observed in the experimental group.

Although the between-group comparison for the 10-Meter Walk Test narrowly failed to reach statistical significance ($p = 0.060$), gait velocity demonstrated a significant improvement. This finding is clinically meaningful because gait velocity is derived from walking time and is considered a more sensitive indicator of locomotor recovery. The lack of statistical significance in the 10MWT may be attributed to the relatively small sample size and variability in walking time measurements.

Overall, the present study found that both balance training alone and balance training combined with motor imagery were associated with improvements in balance and gait performance after six weeks. The experimental group demonstrated significantly better post-intervention balance scores and gait velocity than the control group, while the between-group difference in 10MWT completion time was not statistically significant. These findings suggest that motor imagery may be a useful adjunct to balance training in subacute stroke rehabilitation.

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LIMITATIONS AND FURUTE RECOMMENDATIONS

The present study had certain limitations that should be considered when interpreting the findings. First, the sample size was relatively small, this may have limited the statistical power to detect between-group differences, particularly in the 10-Meter Walk Test (10MWT) outcome. Second, the study included only individuals with subacute stroke who met the specified eligibility criteria; therefore, the findings may not be generalizable to individuals with acute or chronic stroke or to patients with different levels of functional and cognitive impairment. Third, Neurophysiological changes associated with motor imagery training, such as cortical activation or neuroplastic adaptations, were not objectively investigated using neuroimaging or electrophysiological techniques and the influence of lesion location, stroke severity, and individual variability in recovery was not analyzed separately.

Larger studies with clearly standardized intervention protocols, adequate statistical power, and longer-term follow-up are needed to confirm these findings and determine whether the observed improvements are maintained over time.

CONCLUSION

The findings of the present study indicate that six weeks of balance training combined with motor imagery training was associated with greater improvement in balance and gait velocity in individuals with subacute stroke compared with balance training alone. The experimental group demonstrated a statistically significant between-group advantage in Berg Balance Scale scores ($p < 0.001$) and gait velocity ($p = 0.046$). Although the experimental group showed a lower mean 10-Meter Walk Test completion time than the control group, the between-group difference was not statistically significant ($p = 0.060$). Therefore, motor imagery training may be considered a potential adjunct to conventional balance training for improving balance and gait velocity after subacute stroke.

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