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Comparison Between Modified Constraint-Induced Movement Therapy and Motor Imagery Training, Both Combined with Plyometric Exercises, On Balance, Gait and Lower-Extremity Function in Chronic-Stage Stroke

Pallavi Prashant Bukate[1], Dr. Samruddhi Kandharkar[2]

[1,2]Pramiladevi Patil College of Physiotherapy, Miraj, Maharashtra, India

Corresponding Author: Pallavi Prashant Bukate

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ABSTRACT

Background: Stroke may cause persistent deficits in balance, gait and functional mobility. This study compared Modified Constraint-Induced Movement Therapy (M-CIMT) plus plyometric exercises with Motor Imagery Training (MIT) plus the same plyometric exercises in people with chronic-stage stroke.

Methods: This comparative experimental study included 20 individuals with chronic-stage stroke, allocated to Group A (M-CIMT plus plyometrics; n=10) or Group B (MIT plus plyometrics; n=10). Participants were aged 40–65 years, more than six months post-stroke, had an MMSE score above 24 and could walk with or without assistance. Both groups received 30-minute sessions, five days per week for four weeks. Balance, gait and functional mobility were assessed using the Timed Up and Go (TUG), Functional Gait Assessment (FGA) and Modified Rivermead Mobility Index (MRMI), respectively. Paired and independent-samples t-tests were used; $p<0.05$ was considered statistically significant.

Results: Both groups improved significantly in all outcomes ($p<0.001$). Mean TUG time changed from 21.80±2.02 to 14.96±0.97 seconds in Group A and from 21.40±1.72 to 17.19±0.95 seconds in Group B. FGA increased from 15.00±1.83 to 22.80±1.55 in Group A and from 14.90±1.66 to 20.00±1.76 in Group B. MRMI increased from 22.20±2.66 to 33.10±2.92 in Group A and from 22.60±2.07 to 29.50±2.12 in Group B. Post-intervention between-group comparisons favoured Group A for TUG ($p<0.001$), FGA ($p=0.001$) and MRMI ($p=0.006$).

Conclusion: Both interventions were associated with improvements; M-CIMT combined with plyometric exercises showed greater improvement across the measured outcomes. Larger studies are needed to confirm these findings.

Keywords: Stroke; chronic stroke; constraint-induced movement therapy; motor imagery; plyometric exercise; balance; gait; functional mobility.

INTRODUCTION

Stroke is a major cause of long-term disability and can affect motor control, coordination, postural stability and mobility. These impairments may limit independence in transfers, walking and daily activities.

Stroke remains an important public-health concern in India, with epidemiological studies reporting substantial variation in prevalence across regions [1].

Recovery of walking ability does not always mean that gait quality, dynamic balance and functional mobility have returned to normal. Persistent lower-limb impairment can restrict community participation and increase the difficulty of performing everyday activities. Rehabilitation therefore needs to address not only walking but also balance and task-specific functional performance.

Modified Constraint-Induced Movement Therapy (M-CIMT) aims to increase use of the affected limb through repeated, task-oriented practice. Lower-limb applications may include stepping, stair negotiation and other functional activities. Reviews and clinical studies have reported benefits of lower-limb CIMT for motor function, balance, gait and mobility after stroke, although treatment protocols vary [4,8,16–18].

Motor Imagery Training (MIT) involves mental rehearsal of movement without continuous physical execution. It may complement physical rehabilitation by providing practice in motor planning and movement representation. Reviews have reported potential benefits of motor imagery when used in stroke rehabilitation, including for functional recovery and walking-related outcomes [3,19,20]. Plyometric exercise, which uses rapid muscle actions involving the stretch-shortening cycle, may provide an additional training stimulus for strength, power and postural control when appropriately selected [2,12].

Because both lower-limb CIMT and MIT may be useful but operate through different practice strategies, comparing them while keeping plyometric exercise common to both groups may help inform clinical intervention choices. This study aimed to compare the effects of M-CIMT plus plyometric exercises and MIT plus plyometric exercises on balance, gait and lower-extremity functional mobility in individuals with chronic-stage stroke.

MATERIALS & METHODS

Study design and participants

A comparative experimental study was conducted with a convenience sample of 20 individuals with chronic-stage stroke recruited from outpatient departments and nearby hospitals. The study duration was reported as six months. Participants were aged 40–65 years, more than six months post-stroke, had a Mini-Mental State Examination (MMSE) score >24 and were able to walk independently or with an assistive device. Individuals with uncontrolled diabetes mellitus or hypertension, or other neurological or cardiovascular/cardiorespiratory conditions, were excluded.

Intervention

Participants were divided into two groups of 10. Group A received M-CIMT with plyometric exercises. The less-affected limb was constrained and functional tasks were practised using the affected limb, including forward stepping, backward stepping, side stepping, ball kicking and stair climbing. Group B received MIT with plyometric exercises; imagined tasks included forward, backward and side stepping, stair climbing and ball kicking. Both groups performed the same listed plyometric exercises: supine leg press, clamshells, ankle dorsiflexion and foot eversion. Treatment was delivered for 30 minutes per session, five days per week for four weeks, with 10 repetitions per exercise as described in the thesis.

Outcome measures

Balance was assessed using the Timed Up and Go Test (TUG), recorded in seconds. Gait was assessed using the Functional Gait Assessment (FGA). Functional mobility was assessed using the Modified Rivermead Mobility Index (MRMI). Outcomes were measured before and after the intervention.

Statistical analysis

Descriptive statistics were reported as means and standard deviations. Within-group pre- and post-intervention comparisons used paired-samples t-tests. Between-group comparisons used independent-samples t-tests, including comparisons of post-intervention scores and change scores. Normality was assessed using the Shapiro–Wilk test. Statistical significance was set at $p<0.05$.

Ethical considerations

The thesis reports that institutional ethical approval was obtained and written informed consent was collected from participants. The approval committee name and approval/reference number were not provided in the thesis text reviewed for this draft.

RESULTS

Twenty participants completed the study, with 10 participants in each group. Each group included six men and four women. Mean age was 53.7±4.47 years in Group A and 53.0±7.75 years in Group B; the baseline difference was not statistically significant ($p=0.81$). Baseline outcome scores were also comparable between groups.

Table 1. Pre- and post-intervention outcome scores (mean ± standard deviation). Lower TUG time indicates improvement; higher FGA and MRMI scores indicate improvement.

Outcome	Group A: Pre	Group A: Post	Within-group p	Group B: Pre	Group B: Post	Within-group p
TUG (seconds)	21.80 ± 2.02	14.96 ± 0.97	<0.001	21.40 ± 1.72	17.19 ± 0.95	<0.001
FGA	15.00 ± 1.83	22.80 ± 1.55	<0.001	14.90 ± 1.66	20.00 ± 1.76	<0.001
MRMI	22.20 ± 2.66	33.10 ± 2.92	<0.001	22.60 ± 2.07	29.50 ± 2.12	<0.001

Table 2. Between-group comparison of change scores as reported in the thesis. Note: the thesis narrative reports p<0.001 for all change-score comparisons in one discussion summary, while its outcome tables report p=0.001 for FGA and p=0.006 for MRMI post-intervention comparisons. These have been kept distinct here.

Outcome	Group A change	Group B change	Between-group result
TUG (seconds; reduction)	6.84 ± 1.07	4.21 ± 0.78	p<0.001; favoured Group A
FGA (score increase)	7.80 ± 0.63	5.10 ± 0.32	p=0.001; favoured Group A
MRMI (score increase)	10.90 ± 0.74	6.90 ± 0.88	p=0.006; favoured Group A

DISCUSSION

This study compared M-CIMT plus plyometric exercises with MIT plus plyometric exercises in people with chronic-stage stroke. Both groups improved significantly in TUG, FGA and MRMI, while the magnitude of improvement was greater in Group A. The groups were similar at baseline on age and the reported outcome measures, supporting interpretation of the post-intervention differences in the context of the interventions received.

TUG time decreased in both groups, indicating improved performance on a task involving standing, walking, turning and sitting. The larger reduction in Group A may relate to active, repetitive and task-specific use of the affected lower limb during M-CIMT. Previous research has reported improvements in balance and gait following lower-limb CIMT in chronic stroke, and reviews also support potential benefits for lower-extremity motor outcomes [4,8,16–18]. Plyometric exercises may have contributed to improvement in both groups, as lower-limb plyometric training has been associated with gains in strength and postural control after stroke [2,12].

FGA scores increased in both groups, with a larger improvement in Group A. The FGA evaluates walking under different functional conditions and is relevant to dynamic gait balance. Its use in people after stroke is supported by evidence of validity and reproducibility [21,22]. The active practice of stepping, turning-related mobility and

stair tasks in the M-CIMT programme may have provided repeated opportunities to practise functional lower-limb movement. Since both groups also received plyometric exercises, the difference between groups may reflect the additional effect of the active task-practice component rather than plyometrics alone.

MRMI scores also improved in both groups, with a larger gain in Group A. The MRMI assesses mobility-related tasks and has reported reliability, validity and responsiveness in neurological populations [5,23,24]. Repeated functional practice may have helped participants improve performance in mobility tasks, while plyometric exercises may have provided a shared physical training stimulus.

The significant improvement in Group B is also noteworthy. MIT involves mental rehearsal and may support movement planning and motor representation. Reviews of mental practice and motor imagery have reported potential benefits when incorporated into stroke rehabilitation, although findings differ by protocol and outcome [3,19,20]. The current findings suggest that MIT combined with plyometric exercises may be useful, but in this sample it produced smaller changes than M-CIMT combined with the same exercise component.

Interpretation should take account of the study's limitations. The sample was small, participants were recruited using convenience sampling, and the findings apply specifically to chronic-stage stroke. The thesis also notes an unequal male-to-female distribution overall, although each group had the same distribution. The information provided does not establish long-term retention of improvements. Larger, well-described randomized studies with standardized protocols and follow-up assessments are required.

CONCLUSION

Both M-CIMT combined with plyometric exercises and MIT combined with plyometric exercises were associated with significant improvements in balance, gait and lower-extremity functional mobility among individuals with chronic-stage stroke. Greater improvement was observed in the M-CIMT group across all three outcomes. These findings suggest that active, task-specific lower-limb practice combined with plyometric exercises may be a useful rehabilitation approach; confirmation in larger studies is warranted.

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Data Availability: Data availability statement to be confirmed by the author and added if required by the journal.

Declaration by Authors

Ethical Approval: The thesis states that institutional ethical approval was obtained. Please insert the committee name and approval/reference number if required by the journal.

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