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Comparative Effects of Intensive Repetitive Facilitation and Modified Constraint-Induced Movement Therapy on Upper Limb Motor Recovery in Stroke Patients

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ABSTRACT

Stroke is one of the leading causes of long-term disability worldwide, frequently resulting in motor impairment, particularly in the upper limbs. The loss of upper limb function significantly impacts the independence and quality of life of stroke survivors. Rehabilitation interventions aim to restore motor function and improve the overall ability to perform daily activities. To compare the effectiveness of Intensive Repetitive Facilitation Exercise (IRFE) and Modified Constraint-Induced Movement Therapy (MCIMT) in promoting upper limb motor recovery in post-stroke patients. A randomized controlled experimental study was conducted at a rehabilitation center/tertiary care hospital over a period of 6 months. Eligible post-stroke patients were randomly assigned to one of two intervention groups: Intensive Repetitive Facilitation Exercise (IRFE) or Modified Constraint-Induced Movement Therapy (MCIMT). Each group underwent a structured rehabilitation protocol tailored to their assigned therapy. Motor function of the affected upper limb was assessed at baseline and after the intervention using standardized clinical evaluation tools. The outcomes were analyzed to determine the comparative effectiveness of the two approaches in promoting motor recovery. Over a 4-week rehabilitation period, both Intensive Repetitive Facilitation Exercise (IRFE) and Modified Constraint-Induced Movement Therapy (mCIMT) were found to be effective in improving upper limb motor recovery in stroke patients. The IRFE group showed a 33.84% improvement in motor function and an 84.14% reduction in spasticity, indicating its usefulness in initiating movement and reducing muscle tone, especially in patients with severe impairments. The mCIMT group demonstrated a 29.33% improvement in motor function and an 86.13% reduction in spasticity, along with greater functional use of the affected limb in daily tasks like grooming and dressing. These outcomes suggest that mCIMT's task-specific, high-intensity approach may better promote neuroplasticity and purposeful movement. While both therapies are clinically valuable, mCIMT appears more effective for patients with moderate recovery potential. The findings support a staged and personalized rehabilitation strategy, tailored to individual motor capacity and recovery phase. This study confirms that both IRFE and mCIMT are effective in improving upper limb motor recovery in stroke patients. While both interventions led to significant gains in motor control and reduced spasticity, mCIMT showed greater functional improvements, especially in daily activities. Its task-specific, high-intensity approach appears to better promote neuroplasticity, making it a preferred option for patients with moderate recovery potential. The findings support a personalized rehabilitation strategy, with mCIMT recommended as a primary method in community-based stroke recovery programs.

KEY WORDS: INTENSIVE REPETITIVE FACILITATION, MODIFIED CONSTRAINT-INDUCED MOVEMENT THERAPY, MOTOR RECOVERY, STROKE, UPPER LIMB.

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INTRODUCTION

Stroke remains one of the most prevalent causes of long-term adult disability worldwide, affecting approximately 15 million individuals annually. Among these, nearly five million people are left permanently disabled, with upper limb impairment being one of the most common and persistent consequences. This loss of motor function in the upper extremities significantly compromises a person's ability to perform essential activities of daily living (ADLs) such as feeding, dressing, and personal hygiene, thereby reducing independence and overall quality of life1. Given the profound impact of upper limb dysfunction, rehabilitation strategies aimed at restoring motor function are critical. In recent years, the concept of neuroplasticity—the brain's ability to reorganize and form new neural connections—has emerged as a cornerstone of stroke rehabilitation.

Evidence suggests that repetitive, task-specific training is essential for activating neuroplastic changes and facilitating motor recovery [2,3]. Among the various therapeutic approaches, Intensive Repetitive Facilitation Exercises (IRFE) and Modified Constraint-Induced Movement Therapy (mCIMT) have gained prominence. IRFE is grounded in the principles of motor relearning and involves high-frequency, therapist-guided movements that stimulate proprioceptive feedback and voluntary motor responses.

This technique aims to enhance neuromuscular coordination and reduce abnormal movement patterns through structured repetition and facilitation [4,5]. Conversely, mCIMT is an adaptation of the original Constraint-Induced Movement Therapy. It focuses on overcoming learned non-use of the affected limb by restricting the unaffected limb and engaging the impaired arm in meaningful, task-based activities.

This approach promotes cortical reorganization and functional recovery by encouraging active use of the affected limb in real-world contexts. Studies have consistently shown that mCIMT can lead to significant improvements in upper limb function and daily performance6–8. Despite the individual effectiveness of both IRFE and mCIMT, comparative evidence remains limited, particularly regarding their relative impact on motor recovery and functional outcomes.

Therefore, this experimental study was designed to evaluate and compare the effects of IRFE and mCIMT on upper limb motor recovery in stroke patients. The goal is to provide clinicians with evidence-based insights to guide the selection of the most appropriate rehabilitation strategy tailored to patient needs and recovery potential.

MATERIALS AND METHODS

1.Study design and Participation: This study was conducted as a randomized controlled experimental trial to rigorously evaluate and compare the therapeutic efficacy of two rehabilitation interventions—Intensive Repetitive Facilitation Exercise (IRFE) and Modified Constraint-Induced Movement Therapy (mCIMT)—in promoting upper limb motor recovery among post-stroke patients. The trial was carried out at the Physiotherapy Outpatient Department of Santosh Hospital, Ghaziabad, equipped with modern rehabilitation infrastructure and staffed by experienced physiotherapists. Ethical clearance was obtained from the institutional ethical committee (REF NO.-SCOP/OCT-24/ECN-94510023673) prior to the commencement of the study.

A total of 30 participants were recruited using a purposive sampling method, targeting individuals who met specific clinical criteria for post-stroke rehabilitation. To ensure unbiased group allocation and reduce selection bias, participants were then randomly assigned to two equal groups (n = 15 each) using a random sampling number table. Group A received IRFE, while Group B underwent mCIMT. This randomization process was critical to maintaining internal validity and ensuring that observed differences in outcomes could be attributed to the interventions rather than pre-existing group differences.

Participants were selected based on a comprehensive set of inclusion and exclusion criteria designed to ensure clinical relevance and homogeneity. Eligible individuals were aged 40 to 70 years, had experienced a first-ever ischemic or haemorrhagic stroke, and were in the subacute recovery phase, defined as 4 to 12 weeks post-stroke onset. Stroke diagnosis and lesion location were confirmed through neuroimaging (CT or MRI), and only those with Middle Cerebral Artery (MCA) involvement were considered, given its strong association with upper limb motor deficits.

Motor recovery status was assessed using the Brunnstrom staging system, and only patients with Stage II to IV upper limb motor function were included, representing mild to moderate impairment. For participants in the mCIMT group, an additional criterion of ≥10° active wrist and finger extension was required to ensure the feasibility of task-specific training, which is central to the mCIMT protocol.

All participants were required to be medically stable, cognitively intact (as assessed by Mini-Mental State Examination, MMSE ≥ 24), and capable of understanding and following verbal instructions. Prior to enrolment, each participant provided written informed consent after receiving a detailed explanation of the study's objectives, procedures, potential risks, and anticipated benefits.

To safeguard participant safety and eliminate confounding variables, exclusion criteria were strictly applied. These included severe cognitive, speech, or language impairments;

a Modified Ashworth Scale (MAS) score greater than 3 in the affected upper limb (indicating severe spasticity); history of multiple or recurrent strokes; Posterior Cerebral Artery (PCA) strokes; orthopaedic conditions affecting the upper limbs (e.g., fractures, joint deformities, or frozen shoulder); and severe cardiopulmonary or systemic illnesses that could interfere with active participation in rehabilitation.

Following enrolment, participants underwent baseline assessments using standardized clinical tools. Motor function was evaluated using the Fugl-Meyer Assessment (FMA), a validated and widely used scale for quantifying motor recovery in post-stroke patients. The FMA assesses reflexes, movement coordination, and voluntary control, with higher scores indicating better motor function. Spasticity was measured using the Modified Ashworth Scale (MAS), which evaluates muscle tone and resistance to passive movement.

These assessments were repeated at mid-treatment and post-treatment intervals to monitor progress and compare outcomes between the two intervention groups. All rehabilitation sessions were conducted under the supervision of qualified physiotherapists, ensuring strict adherence to the intervention protocols and maintaining high standards of patient safety and therapeutic consistency throughout the study duration.

The study was conducted to compare the effects of Intensive Repetitive Facilitation Exercise (IRFE) and Modified Constraint-Induced Movement Therapy (mCIMT) on upper limb motor recovery in stroke patients. Ethical approval was obtained from the Institutional Ethics Committee, and written informed consent was collected from all participants or their legal guardians. Participants were recruited from rehabilitation centers and hospitals in Ghaziabad, screened according to predefined inclusion and exclusion criteria, and randomly assigned to either the IRFE or mCIMT group using a random sampling method. Baseline assessments were conducted using the Fugl-Meyer Assessment (FMA) for upper limb motor function and the Modified Ashworth Scale (MAS) for spasticity. Group A (IRFE) received therapy five times per week for four weeks, with each session lasting approximately 30 minutes.

The intervention focused on repetitive, goal-directed movements of the affected upper limb, emphasizing coordination, speed, and functional relevance. Tasks included reaching, grasping, and lifting, and were initially simplified to match the patient's capabilities. As therapy progressed, task complexity and resistance were gradually increased to challenge motor control and promote neuroplastic adaptation. Each movement was facilitated by a trained therapist to ensure proper activation of target muscle groups and to provide proprioceptive feedback essential for motor relearning. Group B (mCIMT) also underwent therapy five times per week for four weeks, with sessions lasting 30 minutes.

During each session, the unaffected limb was constrained using a mitt or sling to encourage active use of the affected limb. The intervention was centered around task-oriented practice tailored to the patient's functional level, focusing on activities of daily living such as grooming, dressing, buttoning, and pouring water. As patients progressed, the complexity of tasks was increased to enhance motor planning, coordination, and functional independence. The modified format of CIMT was designed to improve compliance and reduce fatigue while maintaining therapeutic intensity.

Table 1. Group A - IRFE (n = 15) & Group B – mCIMT (n = 15)

Scales / Groups	FMA		MAS	
	Pre	Post	Pre	Post
Group A - IRFE	33.87	45.33	1.45	0.23
Group B - mCIMT	38.87	50.27	1.37	0.19

RESULTS

Group A, which received Intensive Repetitive Facilitation Exercise (IRFE), showed an improvement in motor function from a pre-treatment FMA score of 33.87 to a post-treatment score of 45.33. This indicates a substantial gain in upper limb motor recovery. Additionally, spasticity levels, measured by MAS, decreased from 1.45 to 0.23, reflecting improved muscle tone and reduced resistance to passive movement.

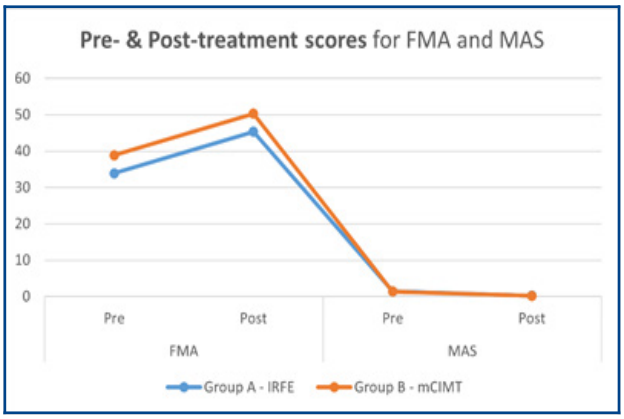


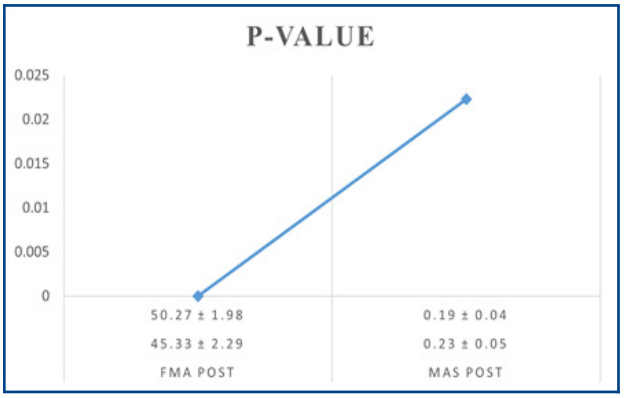
Table 2

Group	FMA Post	MAS Post
Group A - IRFE	45.33 ± 2.29	0.23 ± 0.05
Group B - mCIMT	50.27 ± 1.98	0.19 ± 0.04
p-value	0	0.0223

Group B, treated with Modified Constraint-Induced Movement Therapy (mCIMT), started with a higher baseline FMA score of 38.87, which increased to 50.27 post-treatment, suggesting even greater motor recovery.

MAS scores in this group also showed a reduction from 1.37 to 0.19, indicating a similar improvement in spasticity. Overall, both interventions were effective, but mCIMT demonstrated slightly superior outcomes in both motor function and spasticity reduction. These results support the use of mCIMT for patients with moderate recovery potential, while IRFE remains valuable for those with more severe impairments.

The post-treatment scores for motor recovery and spasticity between the two groups—IRFE and mCIMT—show statistically significant differences, as indicated by the p-values. For motor function, measured by the Fugl-Meyer Assessment (FMA), Group A (IRFE) had a post-treatment score of 45.33 ± 2.29, while Group B (mCIMT) scored 50.27 ± 1.98. The p-value of 0.0000 indicates a highly significant difference between the groups, suggesting that mCIMT led to greater improvements in motor recovery compared to IRFE.



For spasticity, assessed using the Modified Ashworth Scale (MAS), Group A recorded a post-treatment score of 0.23 ± 0.05, and Group B scored 0.19 ± 0.04. The p-value of 0.0223 also indicates a statistically significant difference, though less pronounced than for FMA, showing that mCIMT was slightly more effective in reducing muscle tone and spasticity. These results reinforce the conclusion that while both therapies are beneficial, mCIMT demonstrates superior outcomes, particularly in enhancing voluntary motor control and functional use of the affected limb.

DISCUSSION

This study was conducted to evaluate and compare the effectiveness of Intensive Repetitive Facilitation Exercise (IRFE) and Modified Constraint-Induced Movement Therapy (mCIMT) in promoting upper limb motor recovery among stroke patients. Stroke continues to be a leading cause of long-term adult disability, with upper limb hemiparesis significantly impairing functional independence and quality of life. Consequently, the selection of appropriate, evidence-based rehabilitation strategies is critical to optimizing recovery outcomes and restoring functional capacity [1,9].

The findings revealed that both IRFE and mCIMT resulted in statistically significant improvements in upper limb motor function, as measured by the Fugl-Meyer Assessment (FMA), and reductions in spasticity, as measured by the Modified Ashworth Scale (MAS). Notably, mCIMT demonstrated slightly superior outcomes, particularly in enhancing voluntary motor control and the functional use of the affected limb in daily activities. These results align with recent studies which emphasize the efficacy of mCIMT in improving functional performance and neuroplastic adaptation [7,8].

The theoretical foundation of mCIMT is rooted in the concept of "learned non-use," which has been extensively validated in recent neurorehabilitation literature. By constraining the unaffected limb and encouraging repetitive, purposeful use of the impaired arm, mCIMT stimulates cortical reorganization and use-dependent neuroplasticity6,10. Neuroimaging studies have shown increased motor cortex excitability and functional connectivity following mCIMT, supporting its role in reshaping neural pathways and enhancing motor recovery [3]. In contrast, IRFE emphasizes therapist-guided, high-repetition facilitation of specific movement patterns.

It is particularly beneficial for patients with lower initial motor function, who may lack the voluntary control necessary to engage in task-oriented therapies like mCIMT. Recent evidence suggests that IRFE enhances motor recovery by delivering intensive proprioceptive stimulation, which helps initiate voluntary movement and supports sensorimotor integration4,5. While mCIMT yielded greater overall improvements, IRFE played a critical preparatory role for patients with severe impairments, enabling them to progress toward more advanced rehabilitation. This supports the staged intervention model advocated by recent frameworks in stroke recovery, which recommend beginning with facilitation-based therapies like IRFE and transitioning to task-oriented approaches such as mCIMT to maximize functional gains [11,12].

The improvements observed in both groups can be attributed to the principles of use-dependent neuroplasticity. Repeated, goal-directed movements reinforce neural connections, facilitating functional recovery. mCIMT leverages this through active, task-specific engagement, while IRFE relies on external facilitation to generate internal motor signals—both contributing to synaptic remodeling and motor relearning [13,14]. Importantly, both interventions are cost-effective, require minimal equipment, and are well-suited for community-based rehabilitation, particularly in resource-limited settings. This aligns with current recommendations for scalable and accessible stroke rehabilitation strategies that can be implemented across diverse healthcare environments [1,12].

In conclusion, while mCIMT may offer superior functional outcomes for patients with moderate motor recovery potential, IRFE remains a valuable and effective approach for individuals in the early stages of recovery. These findings underscore the importance of individualized therapy selection, tailored to the patient's motor capacity, cognitive ability, and phase of recovery, to optimize rehabilitation outcomes and improve quality of life for stroke survivors.

The comparative analysis of post-treatment outcomes further reinforces the superiority of mCIMT over IRFE in promoting functional motor recovery. Participants in the mCIMT group achieved higher FMA scores (50.27 ± 1.98) compared to those in the IRFE group (45.33 ± 2.29), indicating more substantial improvements in voluntary motor control and coordination.

Additionally, the MAS scores revealed a slightly greater reduction in spasticity for mCIMT (0.19 ± 0.04) than IRFE (0.23 ± 0.05), with a statistically significant p-value of 0.0223. These findings suggest that mCIMT's task-specific, high-intensity approach not only facilitates neuroplastic changes but also translates into more meaningful functional gains. By actively engaging the affected limb in purposeful activities and overcoming learned non-use, mCIMT offers a more dynamic and patient-driven pathway to recovery, making it a preferred intervention for individuals with moderate motor potential.

CONCLUSION

This study demonstrates that both Intensive Repetitive Facilitation Exercises (IRFE) and Modified Constraint-Induced Movement Therapy (mCIMT) significantly improve upper limb motor recovery and reduce spasticity in stroke patients over a 4-week intervention. The IRFE group showed an FMA improvement from 33.87 to 45.33 and MAS reduction from 1.45 to 0.23. The mCIMT group improved from 38.87 to 50.27 on FMA and from 1.37 to 0.19 on MAS. While both therapies were effective, mCIMT yielded greater functional gains, especially in daily activities, making it preferable for patients with moderate recovery potential. IRFE remains valuable for those with severe impairments, supporting a staged, personalized rehabilitation approach.

Limitations and Future Scope: This study was limited by a small sample size, a short intervention period, and the lack of long-term follow-up, which restricts the generalizability and understanding of sustained therapeutic effects. Being a single-center study, it also did not extensively evaluate functional outcomes such as activities of daily living or psychological factors, and neuroimaging was not used to assess brain-level changes. Future research should involve larger, multicenter trials with extended follow-up to evaluate long-term efficacy. Incorporating quality of life measures, neuroimaging techniques, and exploring combined or home-based therapies could provide deeper insights. Additionally, integrating technology-driven approaches like virtual reality, robotics, and tele-rehabilitation may further enhance stroke recovery and accessibility in diverse settings.

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