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Effects of modified constraint induced movement therapy versus scapular proprioceptive neuromuscular facilitation on upper limb motor function in acute and subacute stroke patients

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Abstract: *According to the World Health Organization, stroke is characterized by the sudden onset of focal neurological deficits resulting from impaired brain function. Following stroke, many survivors experience reduced use of the affected upper limb. Modified Constraint-Induced Movement Therapy (mCIMT) is designed to enhance motor and functional performance of the paretic arm, whereas Proprioceptive Neuromuscular Facilitation (PNF) of the scapula aims to improve muscle activation patterns and joint movement efficiency. This study aimed to compare the effectiveness of mCIMT and scapular PNF in improving upper limb motor function in post-stroke patients. A total of 32 participants were recruited and randomly allocated into two groups: one group received conventional physiotherapy combined with mCIMT, and the other received conventional physiotherapy combined with scapular PNF. Upper limb motor performance was assessed using the Fugl-Meyer Assessment as the primary outcome measure, while the Functional Independence Measure (FIM) served as a secondary outcome measure. Scores recorded on the first and final days of intervention were statistically analyzed. The results indicated that both treatment approaches led to significant improvements in upper limb motor function. However, mCIMT demonstrated superior effectiveness in enhancing overall motor performance, particularly fine motor skills. In contrast, scapular PNF was more effective in reducing pain and improving motor function primarily at the shoulder and scapular region, with no significant improvement observed in fine motor abilities.*

Keywords: *Stroke, Modified Constraint-Induced Movement Therapy (mCIMT), Scapular PNF, Upper Limb Motor Function.*

1. INTRODUCTION

Stroke is defined by the World Health Organization as a rapidly developing clinical sign of focal or global disturbance of cerebral function, lasting more than 24 hours or leading to death, with no cause other than a vascular origin [1]. One of the most common consequences of stroke is contralateral upper limb hemiparesis, which results in significant impairment of upper extremity motor function [1].Modified Constraint-Induced Movement Therapy (mCIMT) is based on the principle of enhancing functional recovery of the affected limb by limiting the use of the unaffected limb, thereby encouraging active use of the paretic limb [3] . The underlying mechanisms of mCIMT in post-stroke neurological recovery include increased synaptic density, enhanced dendritic branching within the motor cortex, and alterations in neurotrophic factor expression [3].Evidence suggests that mCIMT facilitates neurogenesis and angiogenesis by upregulating endogenous hypoxia-inducible factor-1 alpha and vascular endothelial growth factor, which contributes to neuroprotection and functional recovery following cerebral ischemia [3].Proprioceptive Neuromuscular Facilitation (PNF) is a therapeutic exercise approach that utilizes functionally oriented diagonal movement patterns combined with neuromuscular facilitation techniques to stimulate motor responses and improve neuromuscular coordination and control [5]. The primary goal of PNF exercises is to enhance functional movement through facilitation, inhibition, strengthening, and relaxation of muscle groups [5].Scapular PNF specifically targets scapular musculature and is performed using two diagonal movement patterns: anterior elevation with posterior depression, and posterior elevation with anterior depression [5].

2.OBJECTIVES

To evaluate and compare the effectiveness of modified Constraint-Induced Movement Therapy (mCIMT) and scapular Proprioceptive Neuromuscular Facilitation (PNF) on upper limb motor function in individuals following stroke.

3.METHODOLOGY

The study was conducted in Chhatrapati Sambhajinagar and included participants recruited from hospitals and physiotherapy clinics within the city. The duration of the study was six months.A total sample of 32 stroke patients was selected using purposive sampling and divided equally into two groups, with 16 participants in each group. Group A received conventional physiotherapy along with scapular PNF, while Group B received conventional physiotherapy combined with mCIMT. Statistical analysis was carried out using IBM SPSS version 24.

4.PROCEDURE

Participants were selected based on predefined inclusion and exclusion criteria.
Written informed consent was obtained from all participants prior to initiation of the study.
Demographic details were recorded, and participants were informed about the assessment tools and intervention procedures.
Baseline assessment was conducted using the Fugl-Meyer Assessment for upper limb motor function and the Functional Independence Measure (FIM).
Thirty-two participants were randomly allocated into two intervention groups.
Group A (n = 16): Conventional physiotherapy with scapular PNF
Group B (n = 16): Conventional physiotherapy with mCIMT
Outcome measures were reassessed after completion of the intervention period.

GROUP B: CONVENTIONAL INTERVENTION WITH mCIMT
Dosage: Participants wore a sling or mitt on the unaffected limb for 3 waking hours per day.
Activity Schedule: Task-oriented training was provided for 30 minutes twice daily, 5 days per week for 2 weeks.
mCIMT Exercises:
I. Swing Exercise
Aim: To facilitate wrist and finger extension through proximal shoulder girdle control.
Description: The patient leans forward to initiate arm swinging movements and places the affected hand on anti-slip mat positioned on a table.
II. Pushing Away Exercise
Aim: To improve shoulder protraction and elbow extension.
Description: The patient pushes the trunk away using the affected hand placed on an anti-slip mat.
III. Pole Exercise
Aim: To enhance controlled arm movements emphasizing elbow extension and grip.
Description: The patient grasps a pole held by the therapist and performs controlled movements in multiple directions.
IV. Reaching Exercise
Aim: To improve distal arm control with emphasis on wrist and finger extension.
Description: The affected elbow rests on the table while the hand performs reaching tasks on an anti-slip surface.
V. Pinch Exercise
Aim: To improve pinch grip strength and coordination.
Description: The patient grasps and moves objects using a pinch grip.
VI. Grasp Exercise
Aim: To enhance five-finger grasp through intrinsic muscle control.
Description: Objects are grasped, moved, and released using all fingers.
VII. Rice Exercise
Aim: To improve selective finger and thumb movements.
Description: The patient transfers rice using fingertip and thumb movements.

VIII. Marble Exercise
Aim: To improve in-hand manipulation and fine motor control.
Description: The patient picks up marbles sequentially and holds them in the palm.

GROUP A: CONVENTIONAL INTERVENTION WITH SCAPULAR PNF

Participants were positioned in side-lying on the unaffected side, with the therapist aligned along the direction of the intended movement. Preparatory instructions were provided prior to initiating each pattern. The scapula was first guided into an elongated position before active movement was facilitated.Scapular PNF was administered using two diagonal patterns:

1. Anterior elevation and posterior depression
2. Posterior elevation and anterior depression

Each pattern was performed for 10 repetitions across 3 sets. Rhythmic initiation and repeated contraction techniques were incorporated.Rhythmic Initiation**:** Used to promote relaxation, improve coordination, and normalize movement patterns.Repeated Contractions**:** Applied to enhance active range of motion, muscle strength, and movement control.

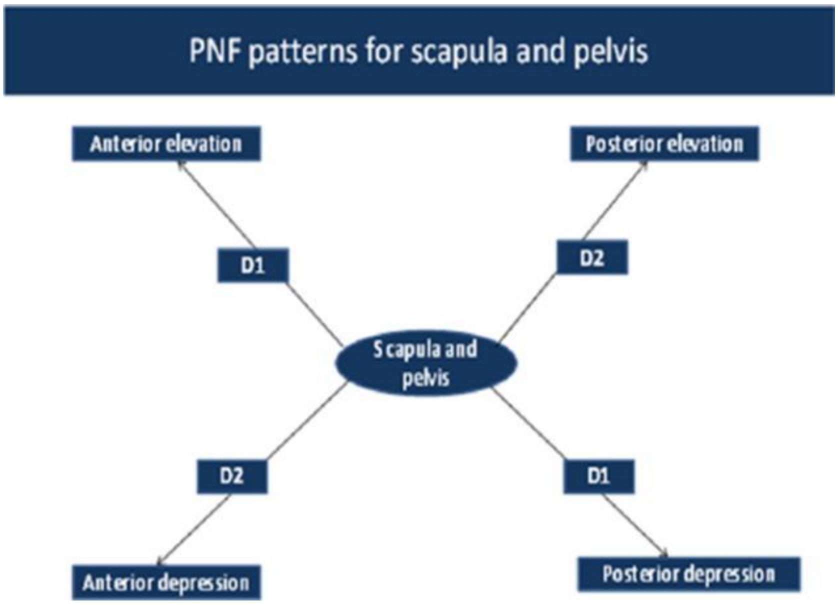

fig.1

5. RESULTS: Comparison of treatment outcome based on effect size [clinical significance]

Variable	Group	Effect size	Result
Fugl-Meyer Assessment	Group A	1.55	Group B is significant
	Group B	1.76	
Functional independence scale	Group A	1.64	Group A is significant
	Group B	1.36	

Based on the paired sample test and Cohen's D Clinical Effect Size, we could conclude that Group B has indicated significant outcome post treatment for Fugl-Meyer Assessment and Group A has indicated better outcome post treatment for Functional independence scale

6.DISCUSSION:

The present study examined and compared the effectiveness of Modified Constraint-Induced Movement Therapy (mCIMT) and Scapular Proprioceptive Neuromuscular Facilitation (PNF), each administered alongside conventional physiotherapy, on upper extremity recovery in individuals following stroke. The comparison reveals distinct differences in underlying neurophysiological mechanisms, patterns of motor recovery, sensory outcomes, functional performance, and stage-specific applicability. Neurophysiological Mechanisms

The findings of this study indicate that mCIMT produced greater improvements in upper limb motor recovery when compared to scapular PNF. This superiority can be attributed to the principle of use-dependent cortical reorganization associated with mCIMT. By restricting the unaffected limb and compelling use of the paretic limb, mCIMT stimulates neuroplastic changes within the motor cortex, including increased synaptic formation, enhanced dendritic branching, and expansion of cortical representation of the affected upper extremity. These mechanisms directly support recovery of voluntary motor control.In contrast, scapular PNF primarily facilitates recovery through peripheral and spinal pathways. Its effects are largely mediated through enhanced proprioceptive input, muscle irradiation, and neuromuscular re-education, which may have a comparatively limited direct influence on cortical reorganization.

Upper Extremity Motor Recover. Greater improvements were observed in distal upper limb motor functions, particularly wrist and finger movements, in the mCIMT group. Recovery of voluntary wrist and finger extension is strongly linked to corticospinal tract integrity and is considered a key predictor of hand dexterity. Task-oriented activities targeting fine motor control in mCIMT likely contributed to the significant gains noted in the hand and wrist components of the Fugl-Meyer Assessment (FMA).Conversely, the scapular PNF group demonstrated minimal improvements in distal joint range of motion and fine motor control, reflecting the proximal emphasis of the intervention.

Proximal Stability, Pain, and Range of Motion Scapular PNF demonstrated comparatively better outcomes in reducing shoulder pain and improving proximal stability. The analgesic effects observed may be explained by the gate control theory, wherein proprioceptive and pressure stimuli inhibit nociceptive signals at the spinal level. Additionally, muscle relaxation and modulation of Golgi tendon organ activity may have contributed to improvements in shoulder flexion and abduction range of motion. As a result, participants in the PNF group showed greater improvements in the pain-related components of the FMA, while distal motor recovery remained limited relative to mCIMT.

Coordination and Speed of Movement Both intervention groups demonstrated improvements in coordination and movement speed; however, gains were more pronounced in the mCIMT group. Task-specific, repetitive practice inherent to mCIMT likely enhanced motor planning and execution speed. These findings are consistent with previous literature suggesting that CIMT can improve movement speed and coordination, particularly during the acute and subacute stages of recovery. Sensory Recovery

Scapular PNF proved more effective in enhancing sensory recovery compared to mCIMT. The emphasis on proprioceptive facilitation and neuromuscular feedback in PNF likely contributed to improved sensory processing. In the present study, the sensory component of the FMA showed greater improvement in the PNF group, whereas sensory gains in the mCIMT group were comparatively modest.

Functional Independence and Activities of Daily Living Both groups demonstrated improvements in Functional Independence Measure (FIM) scores, although the nature of functional gains differed. Participants receiving scapular PNF showed relatively greater improvements in functional task performance, potentially due to early facilitation of proximal stability, tone regulation, and irradiation effects. In contrast, the restriction of the unaffected limb in mCIMT may have temporarily limited participation in certain daily activities, which could have influenced domains such as communication and social cognition.

Timing and Stage-Specific Effectiveness Scapular PNF appeared particularly beneficial during the early stages of stroke recovery, when voluntary motor control is limited and facilitation techniques are most effective. In contrast, mCIMT demonstrated greater effectiveness during subacute and chronic stages, when patients were capable of active participation in repetitive, task-oriented training. As the present study included participants in both acute and subacute phases, both interventions produced meaningful improvements, though with distinct recovery profiles.

Outcome Measures and Clinical Interpretation While both groups showed improvements in overall FIM scores, it should be noted that the FIM assesses global functional independence and is not specific to upper limb performance. The Fugl-Meyer Assessment, which focuses exclusively on upper extremity motor and sensory function, provided a more precise evaluation of treatment effects. Consequently, conclusions regarding upper limb recovery are primarily based on FMA findings, which favored mCIMT for motor and fine motor recovery, and scapular PNF for pain reduction, sensory improvement, and early functional facilitation.

7.CONCLUSION

Based on the findings of the present study, it can be concluded that both modified Constraint-Induced Movement Therapy and scapular Proprioceptive Neuromuscular Facilitation are effective in improving upper limb motor function following stroke. However, mCIMT demonstrated superior outcomes in enhancing pure motor performance, particularly fine motor skills and distal upper limb control. In contrast, scapular PNF was more effective in reducing pain and improving motor function primarily at the shoulder and scapular regions, with no significant improvement observed in fine motor skills.

8.LIMITATIONS

The study had several limitations. The sample size was relatively small and restricted to a specific age group, which limits the generalizability of the findings. The duration of follow-up was limited, preventing assessment of long-term treatment effects. Additionally, detailed assessment of individual scapular muscles and comprehensive sensory evaluation were not performed; therefore, underlying shoulder pathology or sensory deficits may have influenced the outcomes. Future studies should incorporate more specific and sensitive assessment tools alongside the Fugl-Meyer Assessment. Although the FIM was used as a secondary outcome measure, more upper-limb–specific functional assessment tools would provide a clearer understanding of functional recovery.

9.RECOMMENDATIONS: Normality test using Shapiro-Wilk

Variable	Time Frame	Group A PNF		Group B CIMT	
		z-value	p-value	z-value	p-value
Fugl-Meyer Assessment	Pre	0.964	0.728	0.904	0.093
	Post	0.956	0.596	0.968	0.806
Functional independence scale	Pre	0.920	0.166	0.852	0.015
	Post	0.898	0.074	0.900	0.080

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