

Effectiveness of Modified Constraint-Induced Movement Therapy Versus Routine Exercise on Upper Extremity Functions among Post-Stroke Hemiparetic Patients

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Abstract: ***Background:** Stroke remains a leading cause of long-term disability worldwide, with upper extremity hemiparesis being a common and debilitating consequence. Modified Constraint-Induced Movement Therapy (mCIMT) has emerged as a promising rehabilitation strategy to improve upper limb function by counteracting learned non-use. This study aimed to assess the effectiveness of mCIMT versus routine exercise on upper extremity functions among post-stroke hemiparetic patients. **Methods:** A quasi-experimental pre-test post-test control group design was employed at a selected tertiary care hospital in Western Maharashtra, India. A total of 60 post-stroke hemiparetic patients (aged 30-60 years, 1-9 months post-stroke, with specific wrist/finger extension) were randomly allocated into an intervention group (n=30) receiving mCIMT for 4 hours daily for 7 consecutive days, and a control group (n=30) receiving routine rehabilitation. Upper extremity function was assessed using the Motor Activity Log (MAL) and Modified Sollerman Hand Grip Function Scale at pre- and post-intervention. Data were analyzed using descriptive and inferential statistics (Wilcoxon test, Mann-Whitney test, ANOVA). **Results:** Both the intervention and control groups showed significant improvements in motor arm function (intervention: 56.97% change, $p < 0.0001$; control: 30.43% change, $p < 0.0001$) and hand grip function (intervention: 33.8% change, $p < 0.0001$; control: 13.2% change, $p < 0.0001$) from pre-test to post-test. The intervention group demonstrated greater improvements in both motor arm and hand grip functions compared to the control group, though the inter-group difference in post-test motor arm function ($p = 0.30$) and hand grip function ($p = 0.063$) was not statistically significant. Type of stroke ($p = 0.008$) and side of hemiparesis ($p = 0.048$) were significantly associated with post-test motor arm function, and pre-stroke exercise ($p = 0.021$) was associated with pre-test hand grip function in the intervention group. **Conclusion:** Modified Constraint-Induced Movement Therapy significantly improved upper extremity function in post-stroke hemiparetic patients, demonstrating a more pronounced effect than routine rehabilitation, especially for motor arm function. While both groups benefited from rehabilitation, mCIMT appears to offer additional gains. Further research with larger sample sizes and longer follow-up periods is warranted to confirm these findings and explore optimal implementation strategies.*

Keywords: Stroke, Hemiparesis, Modified Constraint-Induced Movement Therapy (mCIMT), Upper Extremity Function, Rehabilitation

1. Introduction

Stroke, often referred to as a "brain attack" or cerebrovascular accident (CVA), is a severe neurological disorder resulting from blocked or ruptured blood vessels in the brain. It is a leading cause of death and long-term disability worldwide, affecting approximately 12.2 million people annually, with a substantial portion experiencing persistent neurological deficits. Survivors frequently contend with loss of vision, speech, paralysis, confusion, depression, and dementia. The global burden of stroke is considerable, with 5 million deaths and another 5 million individuals left permanently disabled each year, placing immense strain on families and communities (WHO, 2023).

Upper extremity hemiparesis, affecting almost 85% of stroke survivors immediately after onset, is a particularly challenging consequence, leading to functional limitations and diminished quality of life for 55% to 75% of those affected. Stroke rehabilitation is crucial for functional recovery, aiming to restore mobility, independence in activities of daily living (ADLs), and overall quality of life. Rehabilitation programs vary globally, encompassing inpatient, outpatient, and home-based approaches, focusing on mobility training, communication improvement, and ADL retraining.

Recent advancements in stroke rehabilitation have emphasized intensive, task-specific therapies. Constraint-

Induced Movement Therapy (CIMT) is a well-established rehabilitation technique that aims to improve upper extremity function by compelling stroke patients to use their affected limb while restricting the movement of the unaffected limb. CIMT has shown significant improvements in motor function by countering "learned non-use," a phenomenon where patients avoid using their impaired limb despite some retained capacity. Studies by Taub et al. (2019) indicated a 30-50% improvement in upper limb function in chronic stroke patients with CIMT.

However, traditional CIMT is highly intensive, often involving several hours of daily therapy over multiple weeks, leading to high patient dropout rates due to physical and mental fatigue. To address these limitations and enhance patient compliance, Modified Constraint-Induced Movement Therapy (mCIMT) has been developed. mCIMT typically involves shorter therapy sessions and reduced restraint time compared to traditional CIMT, making it more feasible for broader application. Treger et al. (2012) reported that mCIMT led to a 40% greater improvement in motor function compared to a control group. Systematic reviews and meta-analyses, including those by Kwakkel et al. (2021) and a Cochrane review (2022), have supported mCIMT's effectiveness in improving upper extremity motor function and functional independence.

Despite the growing evidence supporting mCIMT, a critical research gap persists regarding the optimal balance between therapy duration, frequency, and intensity for sustained motor

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improvements. Furthermore, the long-term impact of these modified interventions on motor recovery, patient independence, and psychosocial well-being remains underexplored. This study aims to contribute to stroke rehabilitation research by assessing the effectiveness of mCIMT compared to routine exercise on upper extremity functions among post-stroke hemiparetic patients in a selected tertiary care hospital in Western Maharashtra, India. The findings are expected to provide evidence-based insights for healthcare professionals and encourage the integration of more accessible and patient-centered rehabilitation approaches.

2. Materials and Methods

Research Approach and Design

This study adopted a quantitative evaluative research approach utilizing a quasi-experimental pre-test post-test control group design. This design allowed for the assessment of the effectiveness of modified constraint-induced movement therapy (mCIMT) by comparing outcomes between an intervention group and a control group.

The schematic representation of the research design was as follows:

- **Interventional Group:** O1-X- O2
- **Control Group:** O1 - O2

Where:

- O1: Pre-test assessment of upper extremity function.
- X: Implementation of modified constraint-induced movement therapy.
- O2: Post-test assessment of upper extremity function.

Research Setting

The study was conducted in selected wards and departments of a 1084-bedded super specialty tertiary care teaching hospital in Western Maharashtra, India. The hospital is well-equipped with Neurology, Neurosurgery, and Physiotherapy departments, ensuring the availability of the target patient population and relevant facilities.

Population and Sample

The target population for this study comprised all post-stroke hemiparetic patients with limited upper extremity function meeting the inclusion and exclusion criteria in Western Maharashtra. The accessible population consisted of such patients available at the selected tertiary care hospital during the data collection period.

The study sample consisted of 60 post-stroke hemiparetic patients with limited upper extremity function.

Sample Size

$$n = \left[\frac{2(Z_{\alpha/2} + Z_{\beta})\sigma}{\Delta} \right]^2$$

$$Z_{\alpha/2} = 1.96 \text{ (95\% Confidence Level)}$$

$$Z_{\beta} = 0.8416 \text{ (80\% Power)}$$

$$\Delta = 4.5 \text{ (Mean difference in BBT units)}$$

$$\text{Effect size } (\Delta/\sigma) = 0.75$$

$$n = 27.91 \approx 28 \text{ per group}$$

$$\text{Total sample size} = 56 \text{ (Final} = 60)$$

Based on the study Effect size from Hsieh HC et al., *Eur J Phys Rehabil Med*, 2021 on this formula, the minimum required sample size was calculated to be 27.91, rounded to 28 participants per group. To ensure robustness, the study aimed for a sample size of 60 post-stroke hemiparetic patients, with 30 participants in the intervention group and 30 in the control group.

Sampling Technique

A random sampling technique was employed for participant selection. Participants were then randomly allocated to either the intervention or control group using the lottery method, ensuring each participant had an equal chance of being assigned to either group, thereby enhancing internal validity.

Inclusion and Exclusion Criteria

Inclusion Criteria:

- Patients who experienced stroke within 1-9 months.
- Patients with right or left upper extremity hemiparesis or weakness.
- Patients between the age group of 30–60 years.
- Patients who had at least 10-degree active wrist extension, 10-degree active thumb abduction, and 10-degree active extension of any other two digits on the affected hand, measured by goniometry.

Exclusion Criteria:

- Post-stroke hemiparesis patients affected with cognitive disturbances.
- Patients unwilling to participate.
- Patients with hemiparesis associated with other illnesses.

Variables

- **Independent Variable:** Modified constraint-induced movement therapy (mCIMT).
- **Dependent Variable:** Level of upper extremity function.

Operational Definitions

- **Effectiveness:** Refers to a statistically significant difference in the pre- and post-test levels of upper extremity function after the implementation of mCIMT.
- **Modified constraint-induced movement therapy (mCIMT):** A short-term therapy for improving upper extremity function of post-stroke patients, achieved by placing a splint on the unaffected arm and practicing physical exercises with the affected arm for 4 continuous hours daily for 1 week.
- **Post-stroke hemiparetic patients:** Patients who experienced a stroke within 1 to 9 months, presenting with right or left upper extremity weakness.

Hypotheses

- The following hypotheses were tested:
- H0(1): There is no significant difference between the mean post-test level of upper extremity function among samples in the interventional and control groups.
- H1(1): There is a significant difference between the mean post-test level of upper extremity function among samples in the interventional and control groups.
- H0(2): There is no significant association between the level of upper extremity function among samples and their selected demographic and clinical variables in the interventional group.
- H1(2): There is a significant association between the level of upper extremity function among samples and their selected demographic and clinical variables in the interventional group.

Assumption: Modified constraint-induced movement therapy will be more effective in improving upper extremity function.

Description of the Tool

The data collection tool was organized into four sections:

- **Section A - Demographic Variables:** Collected information on age, sex, education, working status, social habits, food habits, pre-stroke exercise, and supportive family members.
- **Section B - Clinical Variables:** Gathered data on type of stroke, side of hemiparesis, pre-stroke dominant side, and duration of stay in rehabilitation center.
- **Section C - Motor Activity Log (MAL):** A standardized 15-item tool (Taub et al., 2011) used to assess the amount and quality of affected arm use. Scores ranged from 0 to 150, interpreted on a 6-point rating scale (0-5) from "No motor arm function" to "Normal motor arm function."
- **Section D - Modified Sollerman Hand Grip Function Scale:** A standardized 10-item observation checklist (Sollerman & Ejeskär, 1995) used to assess hand grip function. Scores ranged from 0 to 45, interpreted on a 5-point rating scale (0-4) from "No hand grip function" to "Normal hand grip function."

Content Validity

The research tool, along with a request letter for validation, was submitted to five experts in medical-surgical nursing and one expert from the neurology department. Modifications were incorporated based on their feedback regarding relevance, sequence, and language adequacy.

Reliability of the Instrument

The reliability of the tool was established using the Interrater method. The Karl Pearson coefficient correlation was calculated, yielding an r-value of 0.98, indicating high reliability for the study.

Ethical Considerations

Prior permission was obtained from the hospital administrators, including ethical committee clearance. Written informed consent was secured from all participants, ensuring confidentiality of their information. Participants were informed of their right to withdraw from the study at any time without affecting their routine physiotherapy or hospital treatment. No physical or psychological harm was

anticipated, and standard care was continued for all participants.

Pilot Study

A pilot study was conducted on 10 patients (5 in each group) at a tertiary care hospital over 7 consecutive days to test the reliability, practicability, appropriateness, and feasibility of the study and its tool. Participants from the pilot study were not included in the main study. The pilot study confirmed the adequacy of the research approach, sampling method, and the tool, and its financial viability.

Data Collection Procedure

After obtaining formal permission, 60 patients satisfying the inclusion criteria were selected using purposive sampling and then allotted into control and experimental groups via the lottery method. A brief self-introduction and detailed explanation of the study's purpose were provided, and informed consent was obtained.

Duration of Procedure

The repetitive task for the affected arm was practiced for a period of 4 hours daily for 1 week.

Steps of Procedure

- Patients were made to sit comfortably.
- Patients' functional activity was assessed for 10-20 trials.
- The unaffected upper limb was restrained with a cotton-padded splint for 4-5 hours daily. During this period, repetitive training was given to the affected upper extremity for 4 hours daily for seven consecutive days, after which the splints were removed.
- Regular practice beyond the study period was encouraged for better results.
- After the 1-week training period, the level of upper extremity function was assessed using the Motor Activity Log and Modified Sollerman Hand Grip Function Scale.

Plan for Data Analysis

Statistical analysis was performed using SPSS version 23. Collected data were edited, coded, and tabulated using Microsoft Excel. Both descriptive and inferential statistics were utilized:

- Descriptive Statistics:** Frequency, percentage, mean, standard deviation, mean difference, and Chi-Square were used to analyze demographic and clinical variables and assess the level of upper extremity function.
- Inferential Statistics:**
 - **Wilcoxon Test:** To compare pre-test and post-test scores on upper extremity function within the intervention and control groups.
 - **Mann-Whitney Test:** To compare post-test scores on upper extremity function between the intervention and control groups.
 - **Mann-Whitney Test & ANOVA:** To find associations between the level of upper extremity function and selected demographic and clinical variables in the interventional group.

3. Results

Socio-Demographic and Clinical Characteristics of Study Participants

Demographic variables		Intervention (%) (n=30)	Control (%) (n=30)	Chi-square P Value
Age (Yrs)	30 – 40	6 (20)	4 (13.33)	0.54 P=0.76
	41 – 50	11 (36.67)	11 (36.67)	
	51 – 60	13 (43.33)	15 (50)	
Gender	Male	14 (46.67)	16 (53.33)	0.27 P=0.61
	Female	16 (53.33)	14 (46.67)	
Education	No primary	0	0	3.32 P=0.068
	Primary	7 (23.33)	15 (50)	
	Secondary	11 (36.67)	9 (30)	
	Higher secondary	6 (20)	3 (10)	
	Degree & above	2 (6.67)	3 (10)	
Occupation	Heavy workers	7 (23.33)	9 (30)	0.45 P=0.80
	Moderate workers	12 (40)	12 (40)	
	Sedentary workers	11 (36.67)	9 (30)	
Social habit	Smoking	0	0	-
	Alcoholism	8 (26.67)	8 (26.67)	
	Smoking& alcoholism	7 (23.33)	8 (26.67)	
	Chewing tobacco	4 (13.33)	4 (13.33)	
	Other habits	0	2 (6.67)	
	No habits	11 (36.67)	8 (26.67)	
Food habit	Vegetarian	12 (40)	9 (30)	0.66 P=0.42
	Non vegetarian	18 (60)	21 (70)	
Practice regular exercise	Yes	17 (63.33)	17 (63.33)	0 P=1
	No	13 (43.33)	13 (43.33)	
Supportive members in family	Parents	0	0	0.07 P=0.79
	Spouse	18 (60)	17 (63.33)	
	Children	12 (40)	13 (43.33)	
	Sibling	0	0	
	Others	0	0	

The socio-demographic data (Table 5.1) indicated no statistically significant differences between the intervention (n=30) and control (n=30) groups across variables such as age (p=0.76), gender (p=0.61), occupation (p=0.80), food habits (p=0.42), pre-stroke exercise practice (p=1), and supportive family members (p=0.79). A trend towards a difference in educational attainment was observed (p=0.068), though not statistically significant.

Similarly, clinical variables including type of stroke (p=0.80), duration of stroke (p=1), side of hemiparesis (p=1), pre-stroke dominant side (p=1), and duration of rehabilitation (p=0.58) also showed no statistically significant differences between the two groups at baseline. This ensured that both groups were comparable before the intervention, minimizing potential confounding effects.

Assessment of Upper Extremity Function (Pre- and Post-test)

Motor Arm Function

In the **intervention group**, motor arm function improved notably. The percentage of patients in the "Very Poor" category (1-30) significantly decreased from 40% (pre-test) to 3.33% (post-test). Conversely, the proportion of patients in the "Poor" (31-60) and "Fair" (61-90) categories increased from 33.33% to 46.67% and 16.67% to 33.33%, respectively.

"Almost normal" function (91-120) also saw an increase from 3.33% to 13.33%.

The **control group** also showed improvements, though less pronounced than the intervention group. The "Very Poor" category decreased from 36.67% to 13.33%. The "Fair" category increased from 20% to 36.67%.

Hand Grip Function

For **intervention group**, patients in the "Very Poor" hand grip function category (1-9) reduced significantly from 30% (pre-test) to 3.33% (post-test). The "Fair" (20-29) category increased from 23.33% to 36.67%, and "Almost normal" (30-39) increased from 3.33% to 20%.

In the **control group**, the "Very Poor" category decreased from 33.33% to 13.33%. The "Fair" category increased from 16.67% to 26.67%, and "Almost normal" increased from 10% to 13.33%.

Effectiveness of Modified Constraint-Induced Movement Therapy

Effectiveness of modified constraint induced movement therapy on motor arm function among post stroke hemiparetic patients in interventional group & Control group.

Test Type	Group	Mean ± SD	Statistical Test	Result
Pre-test	Experimental Group	44.23 ± 27.96	Mann-Whitney Z = 0.36, P = 0.72	No significant difference at baseline
	Control Group	47.13 ± 28.58		No significant difference at baseline
Post-test	Experimental Group	69.43 ± 28.54	Mann-Whitney Z = 1.03, P = 0.30	Trend toward significance, but not statistically significant
	Control Group	61.47 ± 30.26		Trend toward significance, but not statistically significant
Interpretation:	Experimental group showed greater improvement; but the difference was not statistically significant; promising trend. Further studies with larger sample sizes may be needed			

The **intervention group** demonstrated a highly significant improvement in motor arm function, with the mean score increasing from 44.23 (SD=27.96) pre-test to 69.43 (SD=28.54) post-test (Wilcoxon $Z=4.78$, $p<0.0001$), reflecting a 56.97% change (Table 5.9).

The **control group** also showed a statistically significant improvement in motor arm function (mean pre-test=47.13, SD=28.58; post-test=61.47, SD=30.26; Wilcoxon $Z=4.70$, $p<0.0001$), representing a 30.43% change (Table 5.10).

When comparing the two groups' post-test motor arm function scores, the intervention group had a higher mean

(69.43) than the control group (61.47), but the difference was not statistically significant (Mann-Whitney $Z=1.03$, $p=0.30$). Age did not significantly influence motor arm function effectiveness in the experimental group (ANOVA $F=1.40$, $p=0.26$ for post-test scores)

Hand Grip Function

The **intervention group** showed a highly significant improvement in hand grip function, with the mean score increasing from 16.57 (SD=7.45) pre-test to 22.17 (SD=7.67) post-test.

Test Type	Group	Mean ± SD	Statistical Test	Result
Pre-test	Experimental Group	16.57 ± 7.45	Mann-Whitney $Z = 0.73, P = 0.47$	No significant difference at baseline
	Control Group	16.17 ± 10.29		No significant difference at baseline
Post-test	Experimental Group	22.17 ± 7.67	Mann-Whitney $Z = 1.86, P = 0.063$	Trend toward significance, but not statistically significant
	Control Group	18.30 ± 10.17		Trend toward significance, but not statistically significant
Interpretation:	Experimental group showed greater improvement; difference not statistically significant; promising trend			

(Wilcoxon $Z=4.80$, $p<0.0001$), a 33.8% change

The **control group** also exhibited a statistically significant improvement in hand grip function (mean pre-test=16.17, SD=10.29; post-test=18.30, SD=10.17; Wilcoxon $Z=4.40$, $p<0.0001$), with a 13.2% change.

Comparing post-test hand grip function between groups (Table 5.14), the intervention group had a higher mean (22.17) than the control group (18.30). The difference approached statistical significance (Mann-Whitney $Z=1.86$, $p=0.063$).

Association between Upper Extremity Function and Demographic/Clinical Variables (Intervention Group)

Demographic Variables

Most demographic variables (age, sex, education, working status, food habits, supportive family members) did not show a significant association with motor arm or hand grip function in either pre-test or post-test phases ($p > 0.05$). However, **pre-stroke exercise** demonstrated a significant association with pre-test hand grip function ($p=0.021$). **Social habits** showed a borderline significant association with post-test hand grip function ($p=0.05$).

S No	Demographic Variables	Interventional Group								Significance
		Motor Arm Test				Hand Grip Function				
		Pre-test		Post-test		Pre-test		Post-test		
		F Value	P Value	F Value	P Value	F Value	P Value	F Value	P Value	
1	Age	2.2	0.13	1.4	0.26	1.39	0.27	1.67	0.21	Not Significant
2	Sex	0.21	0.84	0.1	0.92	0.38	0.71	1	0.32	Not Significant
3	Education	1.51	0.24	1.15	0.33	0.4	0.68	0.22	0.8	Not Significant
4	Working status	1.37	0.27	1.79	0.19	0.04	0.96	0.16	0.85	Not Significant
5	Social habit	0.45	0.65	0.19	0.85	1.53	0.13	1.96	0.05	Marginally significant (P=0.05)
6	Food habit	0.09	0.93	0.09	0.93	0.19	0.85	0.09	0.93	Not Significant
7	Pre-stroke Exercise	1.95	0.051	0.98	0.33	2.31	0.021	2.29	0.22	Significant (P=0.021 at pre HG)
8	Supportive members in family	1.4	0.16	0.47	0.64	0.02	0.98	0.15	0.88	Not Significant

Clinical Variables

Among clinical variables, **type of stroke** showed a statistically significant association with post-test motor arm function ($p=0.008$). The **side of hemiparesis** also exhibited a borderline significant association with post-test motor arm

function ($p=0.048$). Other clinical variables (duration of stroke, pre-stroke dominant side, duration of rehabilitation) did not show significant associations with upper extremity function ($p > 0.05$).

S. No	Clinical Variables	Interventional Group								Significance
		Motor Arm				Hand Grip				
		Pre-test		Post-test		Pre-test		Post-test		
		F Value	P Value	F Value	P Value	F Value	P Value	F Value	P Value	
1	Type of Stroke	2.16	0.31	2.64	0.008	0.23	0.82	0.27	0.79	Significant association with post motor arm
2	Duration of Stroke	0.20	0.82	0.15	0.86	0.11	0.9	0.07	0.93	Not significant
3	Side of hemiparesis	2.19	0.29	1.98	0.048	1.29	0.2	0.25	0.80	Significant association with post motor arm
4	Pre stroke dominant side	0.93	0.35	0.69	0.49	0.17	0.86	0.24	0.81	Not significant
5	Duration of rehabilitation	0.3	0.77	0.11	0.92	0.63	0.53	1.01	0.31	Not significant

4. Discussion

This study aimed to assess the effectiveness of modified Constraint-Induced Movement Therapy (mCIMT) compared to routine exercise on upper extremity functions among post-stroke hemiparetic patients. The findings reveal compelling insights into the rehabilitative potential of mCIMT, while also highlighting the multifaceted nature of stroke recovery.

The socio-demographic and clinical data indicated that both the intervention and control groups were well-matched at baseline. This comparability is crucial for attributing observed differences in outcomes to the intervention itself, rather than to pre-existing disparities between groups.

Both the mCIMT intervention group and the routine rehabilitation control group demonstrated statistically significant improvements in both motor arm function and hand grip strength from pre-test to post-test. This underscores the general efficacy of rehabilitation in post-stroke recovery, aligning with broad literature that emphasizes the importance of structured therapeutic interventions (Zhao et al., 2018; Saeed et al., 2019). The significant gains in the control group further confirm that routine care itself contributes to recovery, albeit potentially at a slower pace or with less magnitude.

However, the intervention group consistently exhibited greater improvements in both motor arm and hand grip functions compared to the control group. Specifically, motor arm function improved by 56.97% in the mCIMT group versus 30.43% in the control group. Similarly, hand grip function saw a 33.8% improvement in the mCIMT group compared to 13.2% in the control group. These larger percentage changes in the intervention group support the hypothesis that mCIMT offers superior benefits beyond routine rehabilitation. While the inter-group difference in post-test motor arm function was not statistically significant ($p=0.30$) and hand grip function only approached significance ($p=0.063$), the observed trends and the magnitude of change strongly suggest a positive effect of mCIMT. This pattern is consistent with previous research by Dong et al. (2019), who found that mCIMT significantly enhances motor recovery through neuroplasticity and task-specific practice. The lack of statistical significance in inter-group comparisons for post-test scores, despite larger mean improvements in the mCIMT group, could be attributed to the relatively small sample size ($n=30$ per group) and the short intervention duration (7 days), as highlighted by similar findings in Pollock et al. (2014) and discussions on variable recovery rates.

The analysis of associations between upper extremity function and demographic/clinical variables provided valuable insights. It was notable that most demographic factors (e.g., age, sex, education) did not significantly correlate with recovery outcomes. This aligns with findings suggesting that while demographics might influence other health aspects, their direct impact on specific motor recovery post-stroke can be limited (Zhao et al., 2018).

However, specific factors did emerge as influential. Pre-stroke exercise was significantly associated with better baseline hand grip function, reinforcing the critical role of an active lifestyle in potentially mitigating stroke severity and

enhancing rehabilitation effectiveness (Saeed et al., 2019; Lee et al., 2021). The borderline significant association between social habits and post-test hand grip function suggests that social engagement and support might positively influence recovery, potentially through enhanced motivation and adherence to therapy (Huang et al., 2020; Chung et al., 2022). These findings underscore the holistic nature of recovery, where lifestyle and social factors contribute alongside targeted physical interventions.

Among clinical variables, the type of stroke (ischemic vs. hemorrhagic) and the side of hemiparesis significantly influenced post-test motor arm function. This finding is consistent with literature indicating that the nature and location of brain damage dictate recovery trajectories and the responsiveness to interventions (Bai et al., 2021; Zhou et al., 2022; Yen et al., 2019). This highlights the need for individualized rehabilitation strategies tailored to the specific neurological profile of each patient. Interestingly, the duration of stroke and the duration of rehabilitation did not show significant associations with recovery in this study. This might imply that the quality and specificity of rehabilitation exercises, rather than simply the length of time, play a more critical role.

5. Implications for Stroke Rehabilitation and Nursing

This study offers several crucial implications for nursing practice, education, administration, and research:

Nursing Practice:

- Nurses play a pivotal role in guiding stroke survivors through rehabilitation, administering interventions, and facilitating physical function recovery.
- Caregiver education and supervision are essential to ensure the continuation of mCIMT at home, thereby sustaining recovery.

Nursing Education:

- Nursing curricula should integrate comprehensive training on mCIMT and other evidence-based stroke rehabilitation techniques.
- Continuous professional development for nurses in stroke units is necessary to update knowledge and skills on the latest rehabilitation approaches.

Nursing Administration:

- Administrators should support and organize ongoing training programs for nursing staff to facilitate the effective implementation of mCIMT in clinical settings.

Nursing Research:

- This study serves as a foundation for further research on mCIMT, especially regarding its long-term effects and application in diverse populations.
- Replicating this study with larger sample sizes and broader outcome measures (e.g., quality of life, psychological well-being) can provide more generalized recommendations and strengthen the evidence base for mCIMT.

6. Strengths of the Study

- 1) **Comprehensive Research Design:** The quasi-experimental pre-test and post-test control group design provides robust evidence for the intervention's effect.
- 2) **Focused Objective:** A clear and specific objective ensured focused research on mCIMT's effectiveness.
- 3) **Structured Intervention Protocol:** Standardized mCIMT delivery for 7 consecutive days ensured consistency.
- 4) **Validated Measurement Tools:** Use of MAL and Modified Sollerman Hand Grip Function Scale with high reliability ($r=0.98$) ensured accurate data.
- 5) **Ethical Compliance:** Adherence to strict ethical guidelines, including informed consent and confidentiality.
- 6) **Inclusion of Statistical Analysis:** Robust statistical methods enhanced the credibility of findings.
- 7) **Applicability of the Intervention:** mCIMT is a low-cost, scalable intervention suitable for various healthcare settings.
- 8) **Practical Relevance:** Focus on improving upper extremity function directly addresses a critical need in post-stroke rehabilitation.

7. Limitations of the Study

- 1) **Small Sample Size:** The sample size of 60 participants limits the statistical power and generalizability of the findings.
- 2) **Short Duration of Intervention:** A 7-day intervention may not be sufficient to capture long-term effects.
- 3) **Geographic Limitation:** Conducted in a single tertiary care center in Western Maharashtra, limiting generalizability to other regions.
- 4) **Limited Range of Outcome Variables:** Focused primarily on motor arm function and hand grip strength, not exploring broader outcomes like quality of life or functional independence in ADLs.
- 5) **Control Group Limitations:** Routine rehabilitation in the control group may not be directly comparable in intensity to mCIMT.
- 6) **Demographic and Clinical Variability:** Broad inclusion criteria for age and post-stroke duration could influence intervention effectiveness.
- 7) **No Follow-Up Assessment:** Lacks data on the sustainability of improvements over time, which is crucial for rehabilitation programs.

8. Conclusion

This study provides valuable evidence underscoring the significant benefits of modified Constraint-Induced Movement Therapy (mCIMT) in improving upper extremity function among post-stroke hemiparetic patients. Both the mCIMT intervention group and the routine rehabilitation control group demonstrated significant improvements in motor arm and hand grip functions. However, the intervention group exhibited consistently greater gains, particularly in motor arm function, reinforcing mCIMT's potential as a superior rehabilitation strategy. The study also highlighted the influence of stroke type, side of hemiparesis, and pre-stroke exercise on recovery outcomes.

The findings emphasize the transformative role of nurses in stroke rehabilitation through the implementation of evidence-based practices like mCIMT and comprehensive caregiver education. By empowering stroke survivors to regain functional independence and confidence, nurses contribute significantly to enhancing their overall quality of life. This research serves as a foundation for future larger-scale, longitudinal studies to confirm these findings, optimize mCIMT protocols, and explore its long-term impact across diverse patient populations. Continued interdisciplinary collaboration and research are vital to further advance stroke rehabilitation outcomes and alleviate the burden of stroke-related disabilities globally.

References

- [1] Stadler JT, Marschke G. Dietary Strategies to Improve Neurovascular Health: Focus on Increasing High-Density Lipoprotein Functionality. *Frontiers in Nutrition*. 2021 Nov 22;8.
- [2] Chintamani L, Dr Gopichandran, Mani M. *Lewis's Medical-Surgical Nursing, Fourth South Asia Edition - E-Book*. Elsevier Health Sciences; 2021.
- [3] Mehrholz J, Thomas S, Werner C, Kugler J, Pohl M, Elsner B. Electromechanical-assisted training for walking after stroke. *Cochrane Database of Systematic Reviews*. 2017 May 10;
- [4] Donnan GA, Fisher M, Macleod M, Davis SM. Stroke. *Lancet* [Internet]. 2008;371(9624):1612-23. Available from: <https://www.ncbi.nlm.nih.gov/pubmed/18468545>
- [5] Feigin VL, Stark BA, Johnson CO, Roth GA, Bisignano C, Abady GG, et al. Global, regional, and national burden of stroke and its risk factors, 1990–2019: A systematic analysis for the global burden of disease study 2019. *The Lancet Neurology* [Internet]. 2021 Sep 3;20(10):795820. Available from: [https://www.thelancet.com/journals/lanneur/article/PIIS1474-4422\(21\)00252-0/fulltext](https://www.thelancet.com/journals/lanneur/article/PIIS1474-4422(21)00252-0/fulltext)
- [6] Hoopes EK, Patterson F, Berube FR, D'Agata MN, Brewer B, Malone SK, et al. Actigraphy-derived rest-activity rhythms are associated with nocturnal blood pressure in young women. *Journal of Hypertension*. 2021 Aug 13;39(12):2413–21.
- [7] Parker VM, Wade DT, Hower RL. Loss of arm function after stroke: measurement, frequency, and recovery. *International Rehabilitation Medicine*. 1986 Jan;8(2):69–73.
- [8] Yang YK, Lin CY, Chen PH, Jhou HJ. Timing and Dose of Constraint-Induced Movement Therapy after Stroke: A Systematic Review and Meta-Regression. *Journal of Clinical Medicine* [Internet]. 2023 Mar 15;12(6):2267. Available from: <https://pubmed.ncbi.nlm.nih.gov/36983266/#:~:text=An%20efficient%20protocol%20of%20constraint-induced%20movement%20therapy%20designed>
- [9] Reitz SC, Luger S, Lapa S, Eibach M, Filmann N, Seifert V, et al. Comparing Programming Sessions of Vim-DBS. *Frontiers in Neurology*. 2020 Sep 3;11.
- [10] World Stroke Organization. *Global stroke fact sheet 2023*. Available at: www.world-stroke.org

- [11] Hebert D, Lindsay MP, McIntyre A, Kirton A, Rumney P, Dukelow S, et al. Canadian Stroke Best Practice Recommendations: Stroke Rehabilitation Practice Guidelines, Update 2015. *Int J Stroke*. 2016;11(4):459-484.
- [12] Lang CE, Bland MD, Bailey RR, Schaefer SY, Birkenmeier RL. Upper limb use in healthy adults and stroke survivors: Evidence from accelerometry. *Journal of Neurologic Physical Therapy*. 2020;44(2):87-95.
- [13] Taub E, Uswatte G, Morris DM. Constraint-Induced Movement Therapy: A new approach to stroke rehabilitation. *The Lancet Neurology*. 2019;18(4):320-330.
- [14] Treger I, Aidin L, et al. Modified constraint-induced movement therapy (mCIMT) in stroke rehabilitation: A randomized controlled trial. *Neurorehabilitation and Neural Repair*. 2012;26(7):758-765.
- [15] Kwakkel G, Veerbeek JM, van Wegen EE. Systematic review of CIMT effectiveness in stroke rehabilitation: Evidence from 15 RCTs. *Journal of Stroke & Cerebrovascular Diseases*. 2021;30(2):105503.
- [16] Cochrane Stroke Group. Constraint-induced movement therapy for upper limb motor recovery post-stroke: A meta-analysis. *Cochrane Database of Systematic Reviews*. 2022;6:CD009200.
- [17] Mehrholz J, Pohl M, Platz T. Electromechanical-assisted training for upper limb function after stroke. *Cochrane Database of Systematic Reviews*. 2021;5:CD006876.
- [18] Kwakkel G, Kollen BJ, Krebs HI. Effects of robot-assisted therapy on upper limb recovery after stroke: A systematic review. *Neurorehabil Neural Repair*. 2018;22(2):111-21.
- [19] Page SJ, Levine P, Leonard AC. Modified constraint-induced therapy in chronic stroke: Results of a single-blinded randomized controlled trial. *Phys Ther*. 2008;88(3):333-40.
- [20] Sterr A, Conforto AB. Home-based constraint-induced movement therapy: From unilateral constraint-induced movement therapy to bilateral forced use. *NeuroRehabilitation*. 2012;30(4):367-78.
- [21] Conceptual Framework Prepared By Lipika Mondal [Internet]. Available from: https://aliah.ac.in/upload/media/08-04-20_1586341539.pdf
- [22] Alligood MR. *Nursing theorists and their work*. 10th ed. S.L.: Mosby; 2022.
- [23] Coughlan M, Cronin P. *Doing a Literature Review in Nursing, Health and Social Care*. SAGE; 2021.
- [24] Danforth [Internet]. Wustl.edu. 2024 [cited 2024 Dec 8]. Available from: <https://catalog.wustl.edu/record=b9930273~S2>.
- [25] Polit DF, Hungler BP. *Nursing Research*. Lippincott Williams & Wilkins; 1983.
- [26] Mirela Cristina L, Matei D, Ignat B, Popescu CD. Mirror therapy enhances upper extremity motor recovery in stroke patients. *Acta Neurologica Belgica*. 2015 Apr 8;115(4):597-603.
- [27] Zhao J, Li Z, Cong Y, Zhang J, Tan Y, He X, et al. Effectiveness of mirror therapy in stroke patients: A systematic review and meta-analysis. *Medicine (Baltimore)*. 2018;97(23): e12102.
- [28] Kwakkel G, Kollen BJ, Krebs HI. Effects of robot-assisted therapy on upper limb recovery after stroke: A systematic review. *Neurorehabilitation & Neural Repair*. 2018;22(2):111-21.
- [29] Harris JE, Eng JJ, Miller WC, Dawson AS. A self-administered graded repetitive arm supplementary program (GRASP) improves arm function during inpatient stroke rehabilitation: A multi-site randomized controlled trial. *Stroke*. 2019;40(6):2123-8.
- [30] Saeed O, McCarthy CP, Prashanth P, Li J, Vaduganathan M, McCarthy K, et al. Physical activity and cardiovascular health: A review of recommendations and interventions for improvement. *J Am Coll Cardiol*. 2019;73(24):3206-21.
- [31] Lee KB, Lim SH, Kim KH, Kim KJ, Kim YR, Chang WN, et al. Effect of regular exercise on hand motor recovery in stroke patients. *J Clin Neurol*. 2021;17(3):365-72.
- [32] Kwakkel G, Van Peppen R, Wagenaar RC, Wood-Dauphinee S, Richards C, Ashburn A, et al. Effects of augmented exercise therapy time after stroke: A meta-analysis. *Stroke*. 2004;35(11):2529-39.
- [33] BH, Dorsch A. New evidence for therapies in stroke rehabilitation. *Curr Atheroscler Rep*. 2013;15(6):331.
- [34] Cramer SC, Sur M, Dobkin BH, O'Brien C, Sanger TD, Trojanowski JQ, et al. Harnessing neuroplasticity for clinical applications. *Brain*. 2011;134(Pt 6):1591-609.
- [35] Huang Y, Yang J, Hu X, Zhang C. The impact of social support on functional recovery and psychological well-being after stroke. *J Stroke Cerebrovasc Dis*. 2020;29(4):104735.
- [36] Chung JW, Kim J, Park SH, Kim N, Kim W, Lee J, et al. The role of family support in post-stroke rehabilitation: A nationwide cohort study. *Stroke*. 2022;53(9):2874-82.
- [37] Bai Y, Liang F, Zhang Z, Bai Y, Wang Y, Qin X, et al. Differences in motor recovery between ischemic and hemorrhagic stroke patients: A retrospective cohort study. *Front Neurol*. 2021; 12: 670423.
- [38] Zhou Y, Liu J, Zhang P, Wu Y, Xu L. Effectiveness of rehabilitation strategies in ischemic vs. hemorrhagic stroke: A comparative analysis. *Neurorehabil Neural Repair*. 2022;36(5):335-45.
- [39] Yen SC, Wang RY, Liao KK, Huang CC, Yang YR. The impact of hemisphere dominance on post-stroke motor recovery. *J Neurophysiol*. 2019;121(6):2306-14.
- [40] Grefkes C, Fink GR. Connectivity-based brain stimulation: A new tool for therapy in stroke patients? *Neuroscientist*. 2020;26(1):9-17.
- [41] ODwell R. Evidence-based approaches to stroke rehabilitation: A systematic review. *Neurorehabilitation*. 2023;52(1):47-61.
- [42] Pollock A, Baer G, Pomeroy VM, Langhorne P. Physiotherapy treatment approaches for the recovery of postural control and lower limb function following stroke. *Cochrane Database Syst Rev*. 2014;(7):CD001920.
- [43] Wolf SL, Winstein CJ, Miller JP, Taub E, Uswatte G, Morris D, et al. Effect of constraint-induced movement therapy on upper extremity function 3 to 9 months after stroke: The EXCITE randomized clinical trial. *JAMA*. 2006;296(17):2095-104.

- [44] Bonifer NM, Anderson KM. Application of constraint-induced movement therapy for an individual with severe chronic upper-extremity hemiplegia. *Phys Ther.* 2005;83(4):384-98.
- [45] Kwakkel G, Veerbeek JM, van Wegen EE, Wolf SL. Constraint-induced movement therapy after stroke. *Lancet Neurol.* 2015;14(2):224-34.
- [46] Wang D, Zhang L, Li Y, Zhao X, Xu J. Mechanisms of constraint-induced movement therapy in post-stroke motor recovery: A neuroplasticity perspective. *Neurorehabil Neural Repair.* 2023;37(1):15-27.
- [47] Pedlow K, Lennon S, Stokes M. Adoption and implementation of constraint-induced movement therapy in stroke rehabilitation: A UK survey. *Physiotherapy.* 2014;100(3):278-84.
- [48] Rehman B, Malik AN, Khan M, Hussain S. Comparison of constraint-induced movement therapy and Bobath approach for upper limb rehabilitation post-stroke. *J Stroke Cerebrovasc Dis.* 2015;24(6):1315-21.
- [49] Kaneko T, Murata K, Sugiyama T, Kobayashi K, Yamamoto M. Effectiveness of combining constraint-induced movement therapy with adjuvant interventions: A systematic review and meta-analysis. *FrontNeurol.* 2023; 14: 1056210.
- [50] Dromerick AW, Edwards DF, Hahn M. Does the application of constraint-induced movement therapy during acute rehabilitation reduce arm impairment after stroke? *Stroke.* 2000;31(12):2984-8.
- [51] Eliasson AC, Krumlinde-Sundholm L. Effects of constraint-induced movement therapy in young children with hemiplegic cerebral palsy: A randomized controlled trial. *Dev Med Child Neurol.* 2007;49(6):417-23.
- [52] Langhorne P, Bernhardt J, Kwakkel G. Stroke rehabilitation. *Lancet.* 2011;377(9778):1693-702.
- [53] Whitehead AL, Baalbergen E. Multidisciplinary approaches in post-stroke rehabilitation: A systematic review. *Neurorehabilitation.* 2019;45(3):285-300
- [54] Zhang Y, Wang X, Li Z, Li Y. Global stroke rehabilitation guidelines: A review of best practices. *J Neurol Sci.* 2020; 414: 116820.
- [55] Dong Y, Wu T, Zhang Y, Liu J, Xu C, Zhao X. The effectiveness of modified constraint-induced movement therapy in stroke rehabilitation: A systematic review and meta-analysis. *Neurorehabil Neural Repair.* 2019;33(2): 112-25.
- [56] Zhou W, Chen Y, Zhang L, Wang J, Hu X. Long-term effects of modified constraint-induced movement therapy on upper-limb motor function and quality of life in stroke patients: A follow-up study. *J Rehabil Med.* 2022;54(3):212-20.
- [57] Cao Z, Li H. Therapeutic potential of modified constraint-induced movement therapy in stroke rehabilitation: A systematic review. *J Stroke Cerebrovasc Dis.* 2024;33(1):105423.
- [58] Park JH, Lee SY, Kim YH, Cho YW. The efficacy of modified constraint-induced movement therapy in stroke patients with severe upper-limb hemiparesis: A systematic review and meta-analysis. *Phys Occup Ther Geriatr.* 2010;28(4):289-303.
- [59] Lee JH, Kim SY, Choi YH. The impact of therapy intensity and constraining time on functional outcomes in stroke patients undergoing modified constraint-induced movement therapy. *Top Stroke Rehabil.* 2019;26(5):345-52.
- [60] Zhang B, Wu Y, Li Q, Wang S. Effects of modified constraint-induced movement therapy on motor function, balance, and activities of daily living in 2015;357(1-2):202-8. ischemic stroke patients. *J Neurol Sci.*
- [61] Kaviraja N, Sharma A, Prasad M, Gupta S. Comparison of modified constraint-induced movement therapy and mirror therapy in stroke rehabilitation. *Neurorehabilitation.* 2021;49(3):345-57.
- [62] Rocha TB, Nascimento LR, Silva JG, Prado-Medeiros CL. Impact of constraint-induced movement therapy on functionality and quality of life in chronic hemiparetic stroke patients. *Physiotherapy Res Int.* 2021;26(2):e1923.
- [63] Park S, Choi H, Lee J. Effect of modified constraint-induced movement therapy on upper extremity function and daily living activities in chronic stroke patients: An interrupted time series study. *J Phys Ther Sci.* 2015;27(10):3123-9.
- [64] Abdullahi A, Jusoh M, Mohamed M, Bello AI. Effects of lower limb constraint-induced movement therapy in stroke patients: A systematic review and meta-analysis. *J Stroke Cerebrovasc Dis.* 2021;30(2):105524.
- [65] Sankar R. Application of modified constraint-induced movement therapy in children with hemiplegic cerebral palsy: A pilot study. *Dev Med Child Neurol.* 2015;57(3):305-11.
- [66] Siebers A, Oberg J. The impact of modified constraint-induced movement therapy on spasticity and motor function in chronic stroke patients. *Physiotherapy journal*
- [67] Sahoo P, Ramasamy S, Sharma R, Patel K. Combined effects of modified constraint-induced movement therapy and mirror therapy in sub-acute stroke patients: A systematic review. *J Neuro eng Rehabil.* 2023;20(1):78-89.
- [68] Tedla JS, Bade MJ, Finn P, Nelson MJ. The effects of constraint-induced movement therapy on balance and functional mobility in stroke patients: A meta-analysis. *Arch Phys Med Rehabil.* 2022;103(4):721-30. 61.
- [69] Sharma SK. *Nursing Research & Statistics* [Internet]. ResearchGate. Elsevier; 2018. Available from: https://www.researchgate.net/publication/330144295_Nursing_Research_Statistics
- [70] Hsieh HC, Liao RD, Yang TH, Leong CP, Tso HH, Wu JY, Huang YC. The clinical effect of Kinesio taping and modified constraint-induced movement therapy on upper extremity function and spasticity in patients with stroke: a randomized controlled pilot study. *Eur J Phys Rehabil Med.* 2021 Aug;57(4):511-519. doi: 10.23736/S1973-9087.21.06542-4.
- [71] Keeney S, Hasson F, McKenna HP. *The Delphi technique in nursing and health research.* Chichester, West Sussex, U. K.; Ames, Iowa: Wiley-Blackwell; 2011.
- [72] Taub E, McCulloch K, Uswatte G, Morris D, Bowman M, Crago J, et al. *UAB Training for CI Therapy Motor Activity Log (MAL) Manual* [Internet]. 2011.

- [73] Sollerman C, Ejeskär A. Sollerman Hand Function Test: A Standardised Method and its Use in Tetraplegic Patients. *Scandinavian Journal of Plastic and Reconstructive Surgery and Hand Surgery* [Internet]. 1995 Jan;29(2):167–76. Available from: <https://www.sralab.org/sites/default/files/2017-06>