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Case Report

## Efficacy of MCIMT with Auditory Cueing in order to Augment Functional Motor Recovery of Chronic Hemiparetic Arm

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### Abstract

**Background:** Stroke is a leading cause of functional impairments globally, often resulting in long-term disability and a substantial impact on individuals, families, and caregivers. Learned nonuse, a phenomenon where motor deficits persist after a stroke due to central nervous system suppression, is a significant challenge in stroke rehabilitation. Constraint-Induced Movement Therapy (CIMT) is a well-established neurorehabilitation approach based on behavioural training, which includes repetitive task-specific training, behavioural techniques, and constraining the use of the more affected upper extremity. CIMT has been successful in improving functionality in chronic hemiparetic stroke patients, promoting cortical reorganization and neural plasticity.

**Method:** This study involved 60 stroke survivors aged 20 or older, selected purposively and meeting specific criteria. Participants underwent an 8-week Modified CIMT (M-CIMT) program with auditory cueing for the hemiparetic upper limb. Data collection included pre-test and post-test assessments using the Wolf Motor Function Test (WMFT) and the Motor Activity Log (MAL) to evaluate functional activity. The M-CIMT program comprised warm-up sessions, M-CIMT protocols, and cool-down exercises, conducted five days a week.

**Results:** Following participation in the M-CIMT program, significant improvements were observed in WMFT and MAL scores. The mean pre-test score of 46.60 seconds decreased to a mean post-test score of 16.85 seconds, with highly significant t-values of 14.292 and -51.356 and a p-value of 0.0, indicating a strong correlation between the two datasets. The analysis revealed that M-CIMT effectively enhanced upper extremity function in chronic stroke patients.

**Conclusion:** This study highlights the effectiveness of the Modified CIMT protocol, emphasizing repeated use and a distributed practice schedule, in reducing upper-limb impairment and improving upper-limb use and function in chronic stroke patients. The significant improvement in post-test scores underscores the promise of M-CIMT as a valuable approach for upper extremity rehabilitation following chronic stroke, offering hope for enhanced recovery and improved quality of life for affected individuals.

**Keywords:** Stroke; Rehabilitation; Upper Extremity; Constraint-Induced Movement Therapy; Motor Activity

## 1. INTRODUCTION

Stroke, characterized by a sudden interruption of blood flow to the brain resulting in the death of brain cells, is a significant global health concern. According to the World Health Organization (WHO), stroke is defined as "the rapid development of clinical signs and symptoms of a focal neurological disturbance persisting for more than 24 hours or leading to death, with no causes other than vascular origin" (WHO, 2005) <sup>1,2</sup>. Stroke can be broadly categorized into ischemic, accounting for 50% to 85% of cases, and hemorrhagic, representing 1% to 7% <sup>3</sup>.

Beyond the immediate health impact, stroke often leads to lasting functional impairments, making it a substantial burden on individuals and healthcare systems <sup>4</sup>. WHO reports that 20% of stroke survivors require institutional care within three months, and 15% to 30% experience permanent disabilities (AHA, 2009). Prevalence rates vary with age, increasing from

21 per 100,000 in the 20-40 age group to 625 per 100,000 among those aged 60 and older.

One promising concept in stroke rehabilitation is neuroplasticity, the brain's ability to adapt and repair itself. Constraint-Induced Movement Therapy (CIMT) or forced use has shown significant and substantial improvements in upper extremity (UE) function among stroke survivors (Sussan O'Sullivan). CIMT comprises several components, including repetitive task-oriented training, adherence-improving behavioral techniques (such as a daily application of the Motor Activity Log, home diaries, behavioral contracts, caregiver contracts, home exercise protocols, daily diaries, and home skill assignments), and an emphasis on the use of the affected extremity, typically involving the use of a mitt for restriction or other methods to encourage repetitive use of the more affected arm <sup>5</sup>.

This study aims to evaluate the effects of Modified CIMT (M-CIMT) combined with Proprioceptive Neuromuscular

Facilitation (PNF) on improving upper limb function in patients who experienced their first stroke within the previous 5 to 12 months, as suggested by D.M. Morris et al. in 2006. By exploring the potential benefits of M-CIMT and PNF in this context, we hope to contribute valuable insights into enhancing the rehabilitation of individuals recovering from stroke-related upper limb impairments <sup>6</sup>.

## 2. OBJECTIVE OF THE STUDY

The primary objective of this study is to assess the effectiveness of an 8-week Modified Constraint-Induced Movement Therapy (M-CIMT) program combined with auditory cueing in enhancing both the timed and strength-coordinated performance of the hemiparetic upper limb <sup>7</sup>. This investigation aims to evaluate the impact of the M-CIMT intervention on individuals who have experienced a stroke and are grappling with upper limb motor deficits. The study seeks to determine if the proposed therapeutic approach can lead to significant improvements in the functional capabilities of the affected limb, ultimately contributing to the overall rehabilitation and quality of life of chronic hemiparetic stroke patients <sup>8</sup>.

Additionally, the study aims to examine any potential correlations between the utilization of auditory cueing as a complementary component of the M-CIMT program and the observed enhancements in timed and strength-coordinated performance. This exploration intends to shed light on whether auditory cueing serves as an effective adjunctive method in optimizing motor recovery <sup>9</sup>.

By comprehensively investigating these objectives, we aspire to provide valuable insights into the potential benefits of M-CIMT with auditory cueing as a promising approach in stroke rehabilitation, particularly for individuals experiencing chronic hemiparesis <sup>10</sup>.

## 3. MATERIALS AND METHODS

### 3.1 Data Collection Source and Ethical Clearance

The data for this study were collected from the Neuroscience Department of Geetanjali Hospital, in accordance with predefined inclusion and exclusion criteria. The hospital's resources and facilities were instrumental in conducting the research, ensuring that the selected subjects met the eligibility criteria for participation. Prior to commencing data collection, ethical clearance was obtained from the Human Ethics Committee of Geetanjali University, Udaipur, to ensure that the study adhered to the highest ethical standards and principles.

### 3.2 Study design and requirement

The study design employed in this research was experimental, facilitating a systematic evaluation of the intervention's effects on chronic hemiparetic arms. A total of 60 subjects were enrolled in the study, selected in accordance with specific eligibility criteria to ensure the appropriateness of their inclusion. To establish these eligibility criteria, the Extremity Constraint-Induced Therapy Evaluation (EXCITE) was utilized as a foundational tool, ensuring that individuals met the necessary prerequisites for study participation. In the subsequent stages of data analysis, which have been completed, t-tests and the Pearson Product Moment Correlation (r-value) were employed to thoroughly scrutinize the study's outcomes and uncover any potential relationships between the variables under examination. These statistical methods provided valuable insights into the impact and effectiveness of the intervention on functional motor recovery in chronic hemiparetic arms, offering a comprehensive perspective on the study's findings

### 3.3 Inclusion Criteria for Study

To ensure the study's integrity and the appropriateness of the participant pool, stringent inclusion criteria were meticulously defined. Participants were required to be 20 years of age or older, emphasizing the study's focus on adults while accommodating a broad age range. Gender was not a restrictive factor, fostering a diverse and representative sample that acknowledged potential gender-related differences in motor recovery. Specific motor function prerequisites were established, encompassing an active wrist extension of at least 10 degrees, thumb abduction/extension of at least 10 degrees, and the ability to extend at least two additional digits by at least 10 degrees. These criteria ensured that participants possessed a foundational level of motor function essential for the study's assessments and interventions.

Additionally, a Modified Ashworth Scale (MAS) score of less than 2 was required, indicating limited muscle spasticity among participants. This criterion aimed to mitigate potential confounding influences of excessive muscle spasticity on study outcomes. Furthermore, participants needed to have a Visual Analog Scale (VAS) score of 4 or less, indicating relatively low levels of pain or discomfort. This criterion ensured that individuals could engage comfortably in the study's interventions and assessments without significant discomfort. The inclusion criteria were thoughtfully selected to uphold the study's scientific rigor, enhance result validity, and ensure that the research was conducted on a population most relevant to the study's objectives.

### 3.4 Exclusion Criteria for study

Potential participants were excluded from the study if they met any of the following criteria:

Scoring less than 24 on the Standard Mini Mental Status Examination (SMMSE): In cases where the assessment was required, individuals who scored less than 24 on the SMMSE were excluded, ensuring participants had a certain level of cognitive functioning <sup>11</sup>.

**Excessive Pain:** Individuals experiencing excessive pain in any joint of the paretic extremity were not included in the study to avoid potential exacerbation of discomfort during the intervention.

**Uncooperative Behavior:** Demonstrating uncooperative behavior during the study was grounds for exclusion, as it could interfere with the research process.

**Visual Deficits:** Individuals with visual deficits such as squint, homonymous hemianopsia, nystagmus, or diplopia were excluded from the study, as these conditions could impact their ability to participate effectively.

**Serious Balance Problems:** Having a serious balance problem was a criterion for exclusion, as it could affect the safety and feasibility of the intervention.

**History of Malunited Fractures:** Individuals with a history of malunited fractures in the paretic upper extremity were excluded, as this history could potentially impact their response to the intervention.

**Recurrent Strokes or Transient Ischemic Attacks (TIA):** Participants with a history of recurrent strokes more than twice or transient ischemic attacks (TIA) were not included.

**Posterior Circulation Stroke:** Individuals who had experienced a posterior circulation stroke were excluded from the study.

**Diagnosed Conditions:** Conditions such as apraxia, agnosia, or Gerstmann syndrome were grounds for exclusion, as they could confound the study outcomes.

**Intervention and Assessment:** The primary assessments conducted in this study included the Motor Activity Log (MAL) and the Wolf Motor Function Test (WMFT) <sup>12,13</sup>. These assessments were pivotal in evaluating the effects of the 8-week Modified Constraint-Induced Movement Therapy (M-CIMT) program, which incorporated auditory cueing, on the timed and strength-coordinated performance of the hemiparetic upper limb among the study participants. These evaluations aimed to provide valuable insights into the potential benefits of the intervention for individuals recovering from stroke-related upper limb impairments <sup>14</sup>.

## 4. SELECTION OF SUBJECT AND ASSESSMENT

### 4.1 Selection of subject

This study will enroll a cohort of 60 stroke patients, with a primary focus on individuals who have experienced ischemic strokes affecting the middle cerebral artery (MCA). Inclusivity extends to both male and female participants aged between 19 and 60 years. Subject selection will be purposefully conducted to ensure that individuals meeting specific criteria are included in the study. Importantly, participants will not be burdened with any financial costs, as the study exclusively involves non-invasive procedures <sup>15</sup>.

### 4.2 Study Implementation and Equipment

The core of this study revolves around meticulously assessing upper extremity motor function, which constitutes the primary outcomes of interest. To achieve this, a laboratory-based measure, the Wolf Motor Function Test (WMFT), will be employed. Additionally, participants' real-world arm use and functionality will be comprehensively evaluated through interviews utilizing the Motor Activity Log (MAL) <sup>16,17</sup>.

A suite of specialized materials and equipment will be deployed for data collection and the intervention itself. These resources include items such as baskets, boxes, cans, and data collection sheets (specifically designed for recording WMFT and MAL scores) <sup>14</sup>. Essential tools like finger grippers, goniometers for measuring wrist and finger movements, hand-held dynamometers for assessing grip strength, and a hand rehabilitation unit comprising peg boards, switch boards, door knobs, and related items will facilitate the intervention and data collection process. Moreover, auxiliary items like locks and keys, paper clips, pencils for documenting readings, and static cockup splints for constraining the less affected extremity will be utilized. To provide a conducive environment for exercises and assessments showing in figure 1. tables, timers, towels, metronomes, weighing machines, and weights will also be available and shown in figure 2 <sup>18</sup>.



**Figure 1: Patient conducive environmental exercises during the intervention and assessments**



**Figure 2: Materials and Equipment used in study During the intervention and assessments**



### 4.3 Patient Positioning

During the intervention and assessments, patients will be positioned as show in figure 3 strategically to accommodate



*A. Folding towel in specific pattern*



*B. PNF Hold Relax stretch*

**Figure 3: Patient Position during the intervention and assessments**

### 4.4. Comprehensive Rehabilitation Intervention

The core of this study entails an intensive eight-week intervention designed to enhance the motor function of the hemiparetic upper limb. Administered five days a week, the intervention will comprise a total daily engagement of approximately three hours. This comprehensive approach encompasses both supervised interventions, where participants receive direct guidance and supervision, and a home protocol component that involves prescribed home-based exercises and activities. The daily restraint time adheres to the Modified Constraint-Induced Movement Therapy (MCIMT) protocol, totaling approximately five hours. This rigorous intervention framework is poised to maximize the potential for functional recovery in the hemiparetic upper limb of stroke patients.

In essence, this methodology meticulously outlines the process by which this study aims to evaluate the efficacy of an 8-week Modified Constraint-Induced Movement Therapy (M-

the specific requirements of each exercise or evaluation. Chair positions, including side, front, and front-close configurations, will be employed as needed to optimize the therapeutic process<sup>17</sup>.

CIMT) program combined with auditory cueing on timed and strength-coordinated performance in the hemiparetic upper limb of stroke survivors. By employing a multifaceted approach and a range of assessments and interventions, the study seeks to provide valuable insights into the potential benefits of this therapeutic regimen in the context of stroke rehabilitation.

## 5. RESULT AND DISCUSSION

The study embarked on a thorough exploration of the functional activities of the affected upper extremity among participants, delving into descriptive statistics and significance assessments. The outcomes unveiled striking transformations between the pre and post-intervention scores, pointing unequivocally to the remarkable effectiveness of the Modified Constraint-Induced Movement Therapy (MCIMT) in enhancing the function of the hemiparetic upper limb in individuals afflicted by chronic stroke.

**Table 1: Significance & Standard Deviation (SD) of Pre & Post Intervention for Both Outcomes**

		Mean	N	Std. Deviation	Std. Error Mean	Correlation	Sig.
MAL	PRE	1.1765	60	.45968	.149	.257	.05934
	POST	6.2900	60	.69135	.950	.000	
WMFT	PRE	46.6000	60	29.25991			
	POST	16.8500	60	14.51688			.08925

The analysis revealed compelling data: For the Motor Activity Log (MAL), a noteworthy increase was witnessed in the mean score, soaring from 1.1765 in the pre-intervention phase to a remarkable 6.2900 in the post-intervention phase. Furthermore, the standard deviation (SD) showed a slight elevation from 0.45968 to 0.69135. In the case of the Wolf Motor Function Test (WMFT), the results were equally astounding. The mean WMFT score plummeted from 46.6000

(pre-intervention) to an astonishing 16.8500 (post-intervention), accompanied by a significant reduction in the standard deviation, plummeting from 29.25991 to 14.51688.

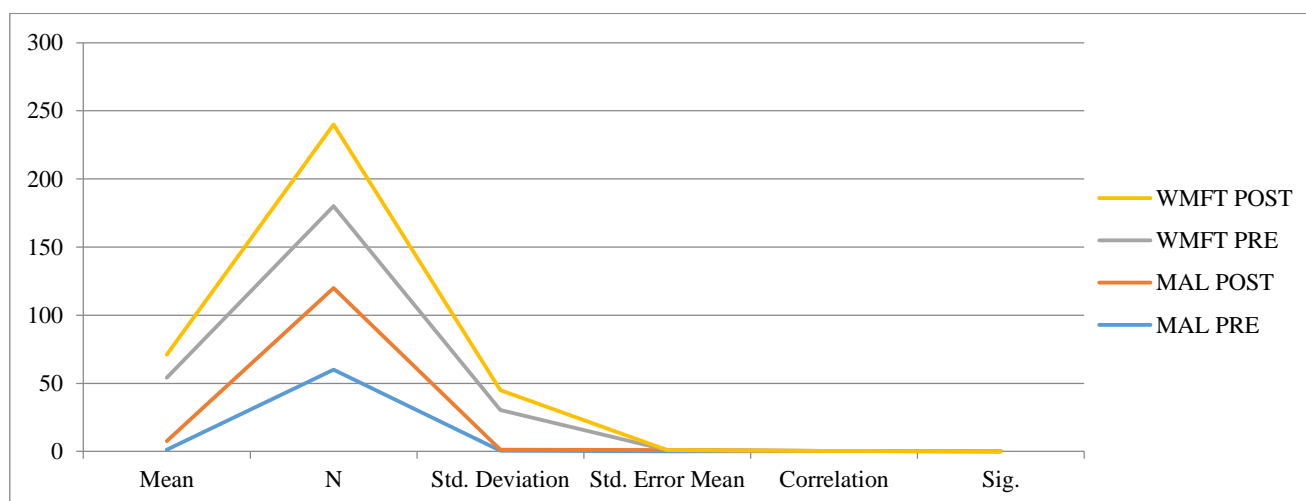
The correlations between the pre and post-intervention scores unveiled intriguing insights: the MAL exhibited a correlation coefficient of 0.257, while the WMFT demonstrated a correlation coefficient of 0.08925.

**Table 2: Descriptive Statistics of Paired Differences, T-Test, Degrees of Freedom (DF), & P-Value for Both Measures Shows Significance**

		Paired Differences					t	df	P
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
MAL	PRE & POST	-5.1134	.77126	.09957	-5.3127	-4.9142	-51.356	59	.000
WMFT	PRE & POST	29.750	16.12412	2.08162	25.5847	33.9153	14.292	59	.000

Diving further into the data, the paired differences between the pre and post-intervention scores were scrutinized. The revelations were striking: For MAL, the mean paired difference stood at -5.1134, indicating a notable improvement. The standard deviation was 0.77126, reflecting the consistency of this advancement. However, the most remarkable aspect was the highly significant p-value ( $p =$

0.000), accentuating the magnitude of this positive change. The realm of WMFT, the mean paired difference surged to an impressive 29.750, a testament to the substantial enhancement in motor function. The standard deviation of 16.12412 indicated consistent progress. Mirroring the trend, the p-value remained strikingly significant ( $p = 0.000$ ), underlining the profound impact of the intervention.

**Figure 4: Increasing Mean and Standard Deviation of Both Measures after Treatment Shows Recovery**

The graphical representation of the data paints a vivid picture of improvement. As participants engaged in the MCIMT Program, their performance showed an upward trajectory in both WMFT and MAL scores. The mean pre-test scores of 46.6000 seconds (WMFT) and 1.1765 (MAL) were eclipsed by the post-test scores of 16.8500 seconds (WMFT) and 6.2900 (MAL). The t-values for WMFT and MAL, 14.292 and -51.356 respectively, accompanied by a p-value of 0.000, emphasized the colossal significance of this transformation. Intriguingly, a robust correlation was uncovered between these two datasets.

## CONCLUSION

The culmination of this study's findings resoundingly affirms the remarkable efficacy of Modified Constraint-Induced Movement Therapy (M-CIMT) in significantly enhancing upper extremity function following cerebrovascular accidents (CVAs) or strokes. Our conclusion is firmly anchored in a wealth of empirical evidence, illuminated by a range of meaningful observations.

The substantial increase in the mean score of the Motor Activity Log (MAL) uncovers a substantial improvement in real-world arm use, reflecting the tangible impact of M-CIMT. Concurrently, the noteworthy reduction in the meantime score of the Wolf Motor Function Test (WMFT) underscores the marked enhancement in motor function among participants

who underwent this transformative therapy. The strong positive correlation observed between MAL and WMFT scores further underscores the consistency and harmony between these assessments. Importantly, the highly significant p-values validate the profound changes witnessed in both the MAL and WMFT assessments, reinforcing the robustness of our findings.

With these compelling and rigorously substantiated outcomes, our study confidently asserts that M-CIMT emerges as a potent and transformative approach for enhancing motor function in individuals grappling with the enduring consequences of chronic CVAs. These positive results serve as a beacon of hope within the realm of stroke rehabilitation, promising a brighter and more functional future for those seeking improved recovery in their affected upper extremity. M-CIMT, with the added element of auditory cueing, holds great promise as a therapeutic avenue for patients seeking meaningful progress and recovery following stroke-related impairments.

## Conflict of interest

No conflict of interest

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## Author statement

All author approved the final manuscript.

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