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Effectiveness of Modified Constraint-Induced Movement Therapy (mCIMT) in Stroke Patients Based on Severity

Niranjan Kumar[1], Niraj Kumar[2], Navneet Badoni[3], Manish Kumar Jha[4]

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Abstract

Introduction: WHO (1970 and still used) defined it as "A stroke is a clinical syndrome characterized by rapidly developing clinical symptoms or signs of focal, and at times global (applied to patients in deep coma and those with subarachnoid hemorrhage), loss of cerebral function, with symptoms lasting more than 24 hours or leading to death, with no apparent cause other than that of vascular origin". This definition includes stroke due to cerebral infarction, primary intracerebral hemorrhage (PICH), intraventricular hemorrhage, and most cases of subarachnoid hemorrhage (SAH); it excludes subdural hemorrhage, epidural hemorrhage, or intracerebral hemorrhage (ICH) or infarction caused by infection or tumor.[1–3]

Aim of the Study: mCIMT on upper extremity and hand functions among individuals with stroke based on the severity as assessed by the UEFM and ARAT.

Methods: The mCIMT was given as treatment intervention for stroke patients. The participants were asked to wear padded safety mitt on their less affected hand during treatment and at least 3 hours at home. All subjects were instructed to take the mitt off during certain activities mainly involving coordinated movements of both the hands simultaneously for example, when driving a car or riding a bike or reading a newspaper.

Discussion: The present study "Efficacy of modified constraint induced movement therapy in improving upper extremity and hand functions in stroke patients" has been started with aim to find out the effectiveness of mCIMT in different severity of stroke. Rinskinijl et al. 2013. Level 3a involves in-hand manipulation exercises, essential for regaining dexterity and bridging the gap between levels 2 and 3b, the latter involving activities of daily living. A database of exercises that can be used for both the dominant and non-dominant hands has been created for each aim at each level. Joachim Liepert et al., 2000. The mechanism of this massive cortical reorganization probably reflects either an increase in the excitability of neurons already involved in the innervation of more-affected hand movements or an increase in excitable neuronal tissue in the infarcted hemisphere, or both.

Conclusion: This study concluded that the patients from moderate to severe post-stroke disability improved better than the mild sever stroke patients so in this case the hypothesis can be rejected and it is accepted that CIMT can be used more beneficially in moderate and severe disability post stroke than the mild post-stroke disability.

Keywords: mCIMT; UEFM; Visual Analog Scale (VAS); Fugl-Meyer Assessment scale and Action research arm test (ARAT) scores.

Author Affiliation: [1]Research Scholar, Dept. of Physiotherapy, OPJS University, Rajgarh, Churu, Sadulpur, Rajasthan 331303, India. [2]Associate Professor, Dept. of Physiotherapy, [3]Professor, Department of Orthopedics, [4]Physiotherapist, Department of Neurology, Shri Guru Ram Rai Institute of Medical & Health Sciences, Patel Nagar, Dehradun, Uttarakhand 248001, India

Corresponding Author: Niraj Kumar, Associate Professor, Dept. of Physiotherapy, Shri Guru Ram Rai Institute of Medical & Health Sciences, Patel Nagar, Dehradun, Uttarakhand 248001, India

E-mail: drnirajkumar25@gmail.com

Introduction

A cerebrovascular accident or brain attack is a sudden loss of brain function due to a disturbance in the blood supply to the brain. (Susan B O'sullivan, Thomas J Schmitz).

WHO (1970 and still used) defined it as "A stroke is a clinical syndrome characterized by rapidly developing clinical symptoms or signs of focal, and at times global (applied to patients in deep coma and those with subarachnoid hemorrhage), loss of cerebral function, with symptoms lasting more than 24 hours or leading to death, with no apparent cause other than that of vascular origin."

This definition includes stroke due to cerebral infarction, primary intracerebral hemorrhage (PICH), intraventricular hemorrhage, and most cases of subarachnoid hemorrhage (SAH); it excludes subdural hemorrhage, epidural hemorrhage, or intracerebral hemorrhage (ICH) or infarction caused by infection or tumor.[1-3]

Strokes can be classified into two major categories: ischemic and hemorrhagic. Ischemic strokes are caused by interruption of the blood supply, while hemorrhagic strokes result from the rupture of a blood vessel or an abnormal vascular structure. About 87% of strokes are ischemic, the rest are hemorrhagic.[1,2]

Epidemiology

Stroke is a global health problem. It is the second commonest cause of death and fourth leading cause of disability worldwide (Strong 2007).[4]

Stroke is one of the main health problems in the Western world (Roger et al., 2011).[5] Because about 80% of the survivors have an upper limb paresis immediately after stroke onset (Nakayama et al., 1994).[6] A wide range of interventions have been developed to improve upper limb function (Langhorne et al., 2009).[7]

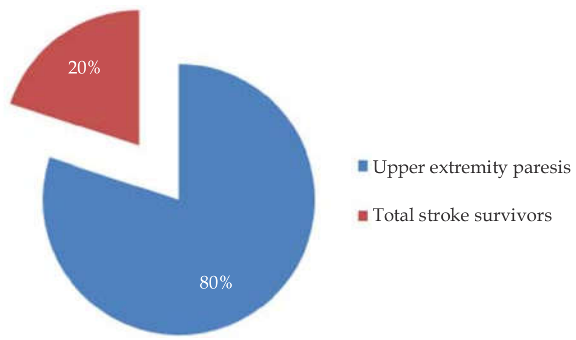

Fig. 1: Epidemiology

Stroke is a leading cause of functional impairment, with 20% of survivors requiring institutional care after 3 months and 15%–30% being permanently disabled (Steinwachs 2000).[8]

Stroke is a life-changing event that affects not only the person who may be disabled, but their family and caregivers. Utility analyzes show that a major stroke is viewed by more than half of those at risk as being worse than death (Dalal P 2004).[9]

Organized provisions of care in a stroke unit have been found to increase the number of patients who survive, return home, and regain functional independence in their everyday activities (Stroke Unit Trial lists Collaboration 1997).[10] However implementation of such organized care for stroke is limited and inadequate in low and middle income countries, especially in a country like India where resources for rehabilitation are scarce (Peter Langhorne 2012).[11]

Constraint-induced movement therapy is a form of rehabilitation therapy that improves upper extremity function in stroke and other Central nervous system damage victims by increasing the use of their affected upper limb.[15]

CIMT (constraint-induced movement therapy) by Taub, CIMT is a neurorehabilitation approach developed by behavioral neuroscientists Dr. Edward Taub and colleagues.

CIMT technique has following basic components:

The original CIMT treatment protocol is clearly described and includes three main elements (Morris et al., 2006).[16]

1. Repetitive, task-oriented training of the more impaired upper limb for 6 hours a day, on 10 consecutive week days;
2. A transfer package of adherence-enhancing behavioral methods designed to transfer the gains made in the clinical setting to the patient's real-world environment; and
3. Constraining the less impaired upper limb to promote the use of the more impaired upper limb during 90% of the waking hours

Modified CIMT (mCIMT): It was developed later, when use of CIMT clinically was not up to the mark or its application was laborious and time consuming. There were many different alternative modified forms of CIMT were made by defferent researchers.

There are limited evidence suggesting the influence of mCIMT in improvement of upper extremity and hand functions post-stroke based on the severity of lesion

This study will help in fulfilling this crucial question of rehabilitation so that more precise and less time-consuming treatment can be given.

This study can help the physical practitioners in such a way that it will give them a clear idea about in which specific severity of stroke the mCIMT would be most effective rather in which cases of stroke this should not be given.

Review of Literature

Langhorne P and Bernhardt J et al. (2009) concluded cerebrovascular accident (CVA) or brain attack is a sudden loss of brain function due to a disturbance in the blood supply to the brain.

The World Health Organization defined stroke (introduced in 1970 and still used) is "rapidly developing clinical signs of focal (or global) disturbance of cerebral function, lasting more than 24 hours or leading to death, with no apparent cause other than that of vascular origin."[7,12]

Yue X Shi et al. (2012). They concluded afairly strong evidence that modified CIMT could reduce the level of disability, improve the ability to use the paretic upper extremity, and enhance spontaneity during movement time, but evidence is still limited about the effectiveness of modified CIMT in kinematic analysis.[14]

Rinske Nijland et al. (2013) characterizing the protocol for early modified constraint-induced movement therapy in the EXPLICIT-stroke Trial explained that the purpose of the present paper is therefore to describe the essential elements of the mCIMT protocol as developed for the explaining plasticity after stroke (EXPLICIT-stroke) study.[13]

Marina Lucas and Pedrorebiero in 2013[7] concluded that the behavioral and neuro-imaging studies using mCIMT and CIMT promote cortical reorganization. Studies observed that many cortical areas like primary motor cortex, dorsal pre-motor cortex and supplementary motor area are activated by mCIMT and CIMT. However, there is no consensus about why some patients show a greater activation in the affected hemisphere, and why other patients experience a greater activation in the unaffected hemisphere. Consequently, the motor behavior in post-stroke patients is benefited from using mCIMT or CIMT; therefore, this therapy should be taken more into consideration by the professionals, due to its benefit.[15]

Joachim Liepert et al., 2000 concluded that this is the first demonstration in humans of a long-term alteration in brain function associated with a therapy-induced improvement in the rehabilitation of movement after neurological injury.[16]

Kristina Laaksonen 2012 concluded that MEG (magnetoencephalography) provides a suitable tool to study cortical neurophysiological alterations after stroke. We observed a variety of alterations which seem to be significantly related to clinical recovery. In the future, studies with more severe stroke patients and longer follow-up times as well as interventional studies may lead to an improvement of individually designed and well-targeted rehabilitation to maximize the recovery potential after stroke.[17]

VW Mark, E Taub and DM Morris 2006 concluded that in short we now understand that the mature brain is not physiologically stagnant either in health or non-progressive disease. Significant plastic brain reorganization can occur within hours of environmental or somatic changes that affect sensory input and such change may be adoptive or mal adoptive.[18]

Shama Praveen, 2018 et al. conducted study on mirror therapy and thermal stimulation on upper extremity motor functions in post-stroke hemiparetic subjects. Mirror therapy and thermal stimulation was found to be effective in improving functional independence in upper limb post sub-acute stroke. When mirror therapy and thermal stimulation is administered to patients suffering from sub-acute stroke over a period of 4 weeks, it results in an improvement in reaching forwards, grasping, manipulating objects and also improves other fine motor functions of the hand.[20]

Nishu Sharma, 2018 done study on intermittent pneumatic compression and mirror therapy improve hand functions after stroke. The study concluded that hand functions improved by intermittent pneumatic compression and mirror therapy in sub-acute stroke subjects and interventions should be emphasize to restore motor and sensory function.[21]

Sudha Dhami, 2019. mirror therapy and repetitive facilitation was found to be effective in improving functional independence in upper limb post sub-acute stroke. When mirror therapy and repetitive is administer third to patient suffering from sub-acute stroke over a period of 4 weeks, it results in an improvement in reaching forwards, grasping, manipulating objects and also improves others motor functions of the hand.[22]

Materials and Methods

A twelve patents were selected for this study on the basis of randomization selection criteria. The study was done at Neuro-Medicine Department, Arunabh NGO, Indore were diagnosed with Stroke/Cerebrovascular Accident (CVA) were chosen purposively selected as subjects for the study. Twelve stroke patients constituted the study group and were willing to take treatment for 3 -week sessions. The subjects/attendants had explained about the complete study procedure and information about the study had recorded in a consent form dually signed by him. The study was approved by NGO Ethical Review Board (IRB). The study elements had analyzed for Fugl-Meyer Assessment scale and Action Research Arm Test (ARAT) scores in order to evaluate the importance of constraint induced movement (CIMT) technique and the significance of mean differences between pre-intervention and after intervention that further leaded the identification of the effectiveness of CIMT therapy among stroke patients.

Convenient sampling: Patients diagnosed with CVA from neuro medicine department was included in study based on inclusion criteria and exclusion criteria.

Inclusion criteria: First episode of stroke, stroke experienced more than 1 month and less than 6 months prior to study enrollment. Ability to actively extend up to 20 degrees at the wrist as assessed by manual goniometer, A score 24 or more on Mini Mental Status Examination (MMSE), Age 40 to 60 years, Modified Ashworth Spasticity (MAS) Scale 2 or less than 2 in affected upper extremity of 6 muscles (shoulder abductors, elbow flexors and extensors, wrist flexors and extensors, finger flexors and extensors and thumb flexors).

Exclusion criteria: Rigidity of the affected upper extremity, excessive pain in the more affected arm, as measured by a score of ≥4 on a 10 point visual analog scale (VAS), currently participating in any experimental rehabilitation or drug studies (mainly on muscle relaxants and on pain killers) and patients having sensory impairment of hand. Outcome measures- Upper extremity Fugl-Meyer (UEFM) and Action research arm test (ARAT) and Goniometer.

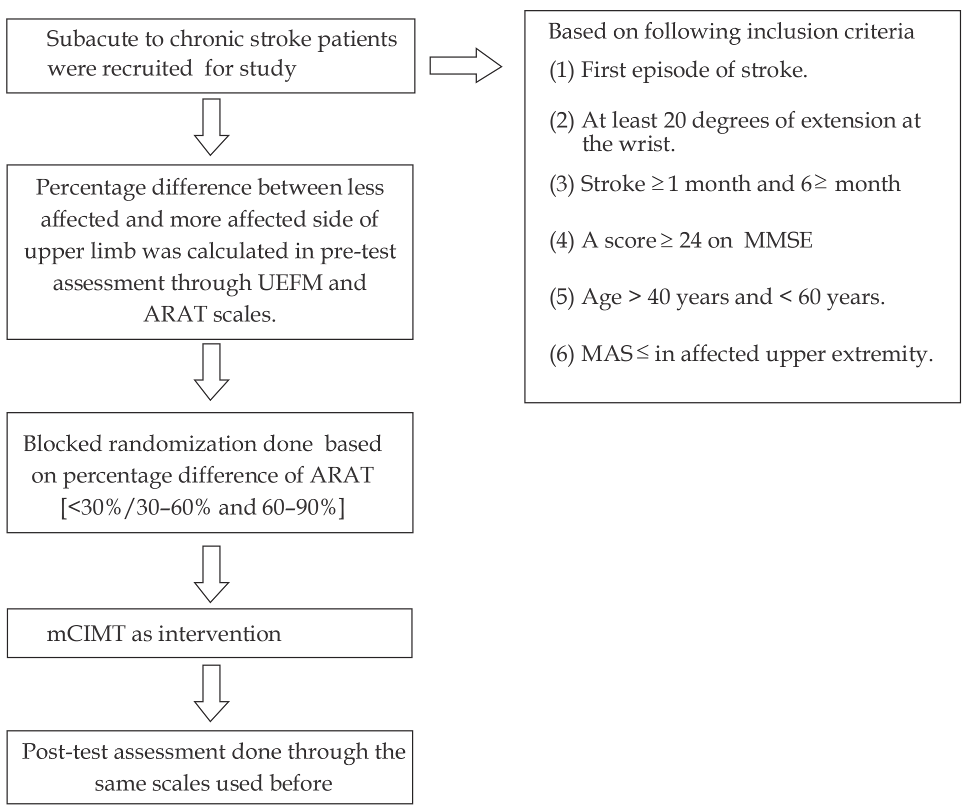

Fig. 2: Data flow diagram

Procedure

Patient's sensory integrity was assessed with touch of cotton ball, prick and hot and cold test tubes on dorsum of hand and forearm. Thereafter the ability of wrist to extend at least up to 20 degrees was assessed by goniometer. A steel half circle (180°) universal goniometer was used with fulcrum over lateral aspect of wrist over triquetrum, proximal arm over lateral to midline of ulna and distal arm lateral to mid line of 5^{th} metacarpal bone.

There were two major assessments (pre-and post-interventions) were taken through two major outcome measures namely upper extremity Fugl-Mayer and action research arm test. In UEFM after checking up the deep tendon reflexes patients were asked to perform certain movements with more affected arm and given scores out of 66 as sum of (0,1,2) corresponding to their no, partial or full movement abilities of arm.

In ARAT patients were given a series of objects in hand to assess hand abilities such as grasp, grip, pinch and gross movements. The patients were given 3 or 0 scores for each the correct or incorrect action performed during test. This test had four subtests having different totals with grand total of 57 and thus scores were given out of 57.

Patients were categorized into three mild, moderate and severe on both the scales. In UEFM the patients whose final score was between 0–27 considered as sever and score between 28–49 considered as moderate and score between 50–60 was considered as mild.

In ARAT the categorization was slightly different than Fugl-Mayer as here the percentage difference between more affected and less affected hand was taken to denote severity grading. The grand total of 57 was considered as 100% and thefinal percentage difference was calculated through subtracting the percentage of more affected arm from the less affected arm. Formula [percentage of less affected arm–percentage of more affected arm].

Now the patients were randomized through blocked randomization in three categories: 0–30% (as mild); 30–60% (as moderate) and 60–90% (as severe).

Thereafter mCIMT was given as treatment intervention for stroke patients. The participants were asked to wear padded safety mitt on their less affected hand during treatment and at least 3 hours at home. All subjects were instructed to take the mitt off during certain activities mainly involving coordinated movements of both the hands simultaneously for example, when driving a car or riding a bike or reading a newspaper.

Repetitive training and constraining

The mCIMT protocol applied in the EXPLICIT-stroke trial retains two of the three main elements of the original form of mCIMT, that is, the repetitive training and the constraining element, and is applied for 15 consecutive weekdays.

Repetitive training

Patients receive 1 hour of individual training on each working day during a 3-week period, starting 1 month after stroke. Depending on the patient's ability to sustain training, the hour can be divided into two 30-minute or four 15-minute sessions per working day.

In line with the original mCIMT protocol, repetitive training consists of 'shaping' and 'task practice'. (RinskeNijland et al., 2012) (Fig. 3).

Fig. 3: mCIMT protocol, repetitive training practice.

(a) *Shaping:* During each session, shaping principles play a dominant role. Shaping is defined as a training method in which a motor objective is approached in small steps by successive approximations (Morris et al., 2006). For instance, the task difficulty can be incrementally increased in accordance with a patient's capabilities, or the requirements for speed performance can be progressively augmented (Morris et al., 2006).

The main objective is to encourage the patient to use the more affected upper limb repeatedly to overcome (or prevent) learned non-use and to induce activity-dependent cortical reorganization (Morris et al., 2006).

Shaping is mainly applied at levels 1 and 2 of the treatment matrix.

(b) *Task practice:* Task practice is a less structured way of training than shaping. Task practice is defined as a training method in which functional tasks are practiced. It is implemented mainly at level 3 of the matrix, when a patient has successfully completed levels 1 and 2 and is able to integrate the improved control of the extensors in functional unilateral tasks (i.e. eating, cutting bread, cleaning a table, ironing or writing). (Rinske Nijland et al., 2012).

Constraining

In the EXPLICIT-stroke program, patients wear a padded safety mitt on the less affected hand during each training session, and for at least 3 hours per day, they were forced to use the more affected limb only. The mitt restricts the ability to use the less affected hand during most tasks, while still allowing protective extension in the elbow in case of imbalance. Patients receive homework at the end of each training session, according to the treatment aims, to encourage them to exercise the more affected limb during the 3 hours when the mitt is worn outside therapy sessions. The homework is discussed and evaluated at the beginning of the next therapy session. (Rinske Nijland et al., 2012) (Fig. 4).

Fig. 4: Constraining training session of affected hand.

Patients are given homework, and patients also have to keep a diary, to encourage them to take the mitt practice seriously. The patients diary is filled in daily and checked by the therapist. The times dedicated to shaping and task practice during the training session, as well as the level and aim that the patient is working on, are documented by patient and therapist. In addition, the times when the mitt is put on and taken off have to be specified in the diary. The information recorded in the patient diary is useful as motivational feedback to the patient by demonstrating improvements.

The purpose of the orthotics and splints was to maintain the fingers/wrist in better alignment to enhance the use of the arm and hand in activities of daily living (ADL).

Environmental adaptations to facilitate use of the plegic hands included door knob turners, terry cloth bath mitts, adaptive drawer pulls, "pencil pushers" (built-up foam on pencils that were used to push buttons), Dycem wraps around utensils, scoop dishes and adaptive cups. The adaptive equipment and orthotics were updated throughout the entire intervention as needed.

Weight-bearing and stretching procedures were given for 1 hour at the beginning of each of the 2 daily sessions in order to reduce tone.

CI therapy was carried out in the second and third hours of the morning and afternoon sessions. Brief periods of conventional procedures such as stretching weight bearing were interpolated in the CI therapy activities to reduce hypertonicity and improve movement as needed. Shaping was used during training. It is a widely used behavioral training technique in which a desired motor or behavioral objective is approached in small steps, by successive approximations.

Shaping is commonly used in CI therapy and clinically it appeared to be particularly important with these patients. The training tasks were carried out in sets of ten trials.

CI Therapy for Plegic Hands 9 sec trials; rests were given between trials and there were longer rests between sets of 10 trials to prevent fatigue. Specific qualitative andquantitative feedback, coaching, modeling and encouragement were used throughout and especially immediately before and after trial performance. The shaping tasks were designed specifically to maximize the subjects' movements in areas that exhibited the most pronounced deficit and that appeared to have the greatest potential for improvement.

Statistical Technique

The raw data were entered into the computer database. The responses of frequencies were calculated and analyzed by using the raw data of 12 subjects. Prevalence of an outcome variable along with 95% confidence limits was calculated. Statistical software, SPSS version 17.0 was used for analysis.

A parametric test, unpaired *t*-test was used to identify the significance of difference between categories of upper extremities Fugl-Meyer and ARAT at pre- and post-intervention in stroke patients.

Paired *t*-test was used to identify the significance of difference in motor recovery in upper extremities score and percentage from ARAT between pre-intervention and post-intervention and handedness in left and right side of arm in stroke patients.

The Karl Pearson's coefficient of correlation had been used to identify the degree and direction of relationship of correlation of age and duration of stroke with upper extremities Fugl-Meyer score and percentage by Action research arm test at pre- and post-intervention stages. Correlation of upper extremities Fugl-Meyer score (hand) score at Pre- and post-intervention stages with Action research arm test score is also identified.

The probability value, $p > 0.05$ was considered as statistically insignificant but the probability value from $p < 0.05$ to $p < 0.1$ was considered as suggestively or poorly significant. The probability value from $p < 0.05$ to $p < 0.01$ was considered as statistically significant while from $p < 0.009$ to $p < 0.001$ was considered as statistically highly/

strongly significant. Following are the notations used to present the significance of observed probability value.

Results

A total of 12 cases of stroke treated as study elements that constituted study group (n = 12) were purposively selected as subjects for the present study. Out of 12 subjects, 9 (75.0%) were male while rest 3 (25.0%) were female. The age of all subjects were obtained in the ranges from 40 to 70 years. The spread of mean age in subjects with stroke were identified in the ranges of 56.00 ± 9.27 years. The following tables are showing the analyzed results with interpretations.

Table 1: The UEFM assessment at pre- and post-interventions

Upper extremity Fugl-meyer score	Pre-intervention		Post-intervention	
	N	%	*N*	%
0–27 (Severe)	11	91.7	3	25.0
28–49 (Moderate)	1	8.3	9	75.0
50–60 (Mild)	0	0.0	0	0.0
Total	12	100.0	12	100.0

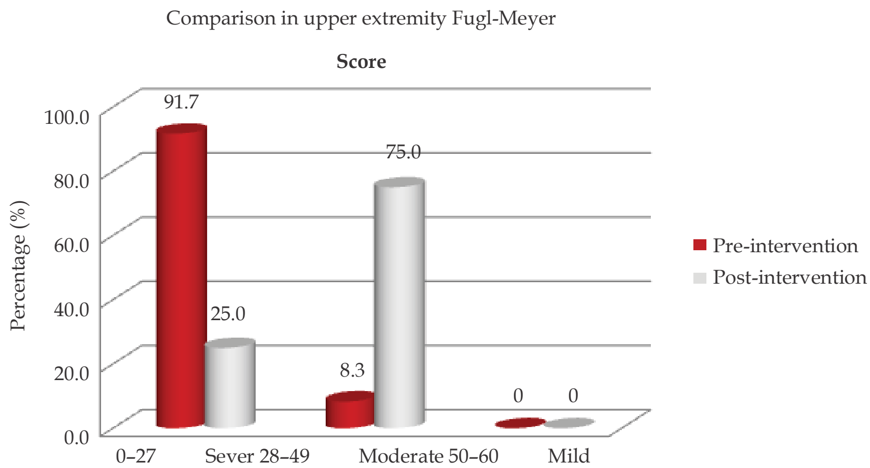

Fig. 5: Multiple bar diagram depicting the comparison in upper extremity Fugl-Meyer score between pre- and post-interventions among stroke patients.

Table 1 and Fig. 5 projected the stroke patients had improved functions after administration of CIMT therapy as the severity of stroke had reduced, easily seen by the increased score obtained after intervention. Major proportion of subjects 11 (91.7%) found with severe stroke while only 1 (8.3%) patient had moderate type severity of stroke at pre-intervention stage.

After administration of CIMT therapy most of the subjects found with reduction in severity of stroke as three-fourths 9 (75.0%) subjects detected with moderate type of stroke while rest one-fourth 9 (25.0%) were left in severe category of stroke.

Henceforth, it is inference that after intervention subjects had improved the functions of affected arm based on severity of stroke that impacted the effectiveness of CIMT therapy among stroke patients.

Table 2: The ARAT percentage at pre-intervention and post-intervention

Action research arm test score (%)	Pre-intervention		Post-intervention	
	N	%	*N*	%
0–30 (Mild)	2	16.7	4	33.3
30–60 (Moderate)	5	41.7	8	66.7
60–90 (Severe)	5	41.7	0	0.0
Total	12	100.0	12	100.0

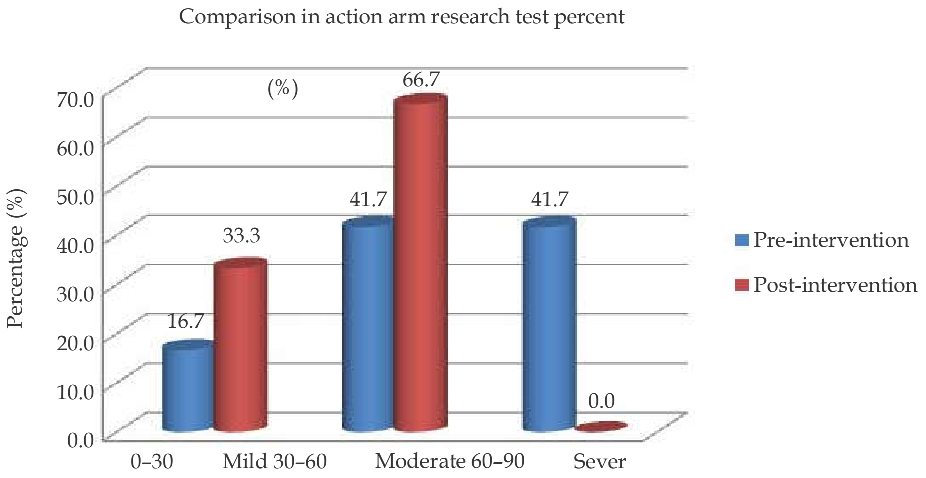

Fig. 6: Multiple bar diagram depicting the comparison in action research arm test (ARAT) percentage between pre and post interventions among stroke patients.

Table 2 and Fig. 6 focused on the percentage (%) of test allocated to stroke patients had improved functions after administration of CIMT therapy as the percentage (%) measured by ARAT was reduced after intervention.

Major proportion of subjects 5 (41.7%) diagnosed with moderate to severe dysfunction shown by percent recorded by Action Research Arm Test (ARAT) while only 2 (16.7%) patient had mild severity of stroke at pre-intervention stage. After administration of CIMT therapy most of the subjects found with decreased percentage recorded on ARAT showed reduction in severity of stroke as two-thirds 8 (66.7%) subjects detected with moderate type of severity while rest one-third 4 (33.3%) were measured in mild severity of stroke.

Henceforth, it is inference that after intervention subjects had improved the functions of affected arm based on severity of stroke that impacted the effectiveness of CIMT therapy among stroke patients.

Table 3: The comparison in mean difference between pre- and post-intervention in UEFM (score) and ARAT (percentage)

Handedness	**Parameter/test**	**Side of lesion**	**Spread** Mean ± SD	**MD**	***t*-value**	**LOS**
Right (n = 10)	Upper extremity Fugl-meyer (score)	Right	20.50 ± 4.01	9.90	11.67	$p < 0.001^{\#}$
		Left	30.40 ± 4.65			
	Action research arm test (%)	Right	54.00 ± 16.71	19.60	6.31	$p < 0.001^{\#}$
		Left	34.40 ± 16.81			
Left (n = 2)	Upper extremity Fugl-meyer (score)	Right	20.00 ± 4.24	6.00	6.00	$p > 0.05^{*}$
		Left	26.00 ± 2.83			
	Action research arm test (%)	Right	58.00 ± 29.70	15.50	1.48	$p > 0.05^{*}$
		Left	42.50 ± 14.85			

- #The mean difference is highly significant at the 0.001 level of significance. *The mean difference is not significant (insignificant) at the 0.05 level of significance. [Degrees of freedom are 9 and 1; MD-Mean Difference; LOS-Level of Significance]
- It was easily seen in the Table 3 that the stroke survivors with right handedness had improved functions after administration of CIMT therapy at right side of lesion had significantly different score and percentage as compared to left side handedness.

- The stroke survivors with left handedness hadn't improved functions at right side of lesion and insignificantly different score for upper extremities Fugl-Meyer (UEFM) and percentage for action research arm test (ARAT) when compared with the scores from UEFM and percentage from ARAT at left side of lesion. The stroke survivors with left handedness were only two and may be due to very small sample size the mean difference was not significant.
- The mean for upper extremity Fugl-Meyer of stroke survivors with right handedness at left side of lesion was 30.40 ± 4.65 points was much higher than right side of lesion was 20.50 ± 4.01 points and the mean difference of 9.90 points between right and left side of lesion was strongly significant (p <0.001) confirmed on statistical ground.
- The mean percentage difference of 19.60% among stroke survivors with right handedness between right and left side of lesion in right (54.00 ± 16.71) side was higher as compared to mean percentage for left (34.40 ± 16.81) side of lesion was strongly significant (p <0.001) confirmed statistically.
- The mean for upper extremity Fugl-Meyer of stroke survivors with left handedness at left side of lesion was 26.00 ± 2.83 points was higher than right side of lesion was 20.00 ± 4.24 points and the mean difference of 6.60 points between right and left side of lesion was statistically insignificant (p >0.05).
- The stroke survivors with left handedness found with mean difference of 15.50% between right and left side of lesion in action research arm test in right (58.00 ± 29.70) side of lesion was much higher as compared to mean percentage for left (42.50 ± 14.85) side of lesion was not statistically significant (p >0.05).
- Henceforth, it is statistically concreted that administration of CIMT therapy among stroke survivors with right handedness was beneficial in both the sides of lesion and reported with improved motor functions of affected arm based on severity of stroke that impacted the effectiveness of CIMT therapy among stroke patients.

Table 4: The comparison in mean differences in handedness and side of lesion between right and left side in UEFM and ARAT

Side of lesion	Parameter/test	Handedness	Spread Mean ± SD	MD	*t*-value	LOS
Right (n = 6)	Upper Extremity Fugl-Meyer (Score)	Right	20.33 ± 3.88	7.67	9.09	$p < 0.001$
		Left	28.00 ± 3.63			
	Action Research Arm Test (%)	Right	58.17 ± 21.19	17.50	5.97	$p < 0.002^{\#}$
		Left	40.67 ± 16.81			
Left (n = 6)	Upper Extremity Fugl-Meyer (Score)	Right	20.50 ± 4.18	10.83	9.29	$p < 0.001^{\#}$
		Left	31.33 ± 5.20			
	Action Research Arm Test (%)	Right	51.17 ± 14.36	20.34	3.85	$p < 0.02^{*}$
		Left	30.83 ± 15.30			

- #The mean difference is highly significant at the 0.001 and 0.002 levels of significance. *The mean difference is significant at the 0.02 level of significance. [Degrees of freedom are 5; MD-Mean Difference; LOS-Level of Significance]
- Table 4 showed that the stroke patients with right and left side of lesions had improved functions after administration of CIMT therapy and significantly different score for upper extremity Fugl-Meyer (UEFM) and percentage for action research arm test (ARAT) between right and left side.
- The mean upper extremity Fugl-Meyer of stroke survivors with right side of lesion at left side handedness was 28.00 ± 3.63 points was much higher than right side handedness was 20.33 ± 3.88 points and the mean difference between right and left side handedness was strongly significant (p <0.001) confirmed on statistical ground.

- The mean percentage difference of 17.50% among stroke survivors with right side of lesion between right and left side handedness observed in action research arm test in right (58.17 ± 21.19) side handedness was much higher as compared to mean percentage for left (40.67 ± 16.81) side handedness was strongly significant (p <0.002) confirmed statistically.
- The mean for upper extremity Fugl-Meyer of stroke survivors with left side of lesion at left side handedness (31.33 ± 5.20) was higher than right side handedness (20.50 ± 4.18) and the mean difference of 10.83 points between right and left side handedness was strongly significant (p <0.001) concluded statistically.
- The stroke survivors with left side of lesion found with mean difference of 20.34% between right and left side handedness in action research arm test in right (51.17 ± 14.36) side handedness was much higher as compared to mean percentage for left (30.83 ± 15.30) side handedness was significant (p <0.02) confirmed statistically.
- Moreover, it is statistically concluded that administration of CIMT therapy among stroke survivors with right and left side of lesion was equally beneficial in both the sides of handedness and reported with improved motor functions regarding severity of stroke that impacted the effectiveness of CIMT therapy among stroke patients.

Discussion

The present study "Efficacy of modified constraint -induced movement therapy in improving upper extremity and hand functions in stroke patients" has been started with aim to find out the effectiveness of mCIMT in different severity of stroke.

Rinski Nijland et al. (2013) the therapy described in the mCIMT protocol is aimed at recovery in terms of neurological repair, by applying an impairment-focused intervention, while preventing the development of compensatory movement strategies. This approach is specified as the bottom-up approach in the EXPLICIT-stroke mCIMT protocol, referring to the hierarchical levels of the International Classification of Functioning, Disability and Health (ICF).[15]

Lepert J, Mitner et al. the foregoing evidence suggests that constraint induced therapy for chronic upper extremity paresis in adults after stroke would be associated with measurable neurophysiologic changes. Taub et al. were the first to demonstrate that CI therapy produces the large changes in brain organization and function, in laboratories he helped to set up changes that were correlative with the large changes in motor function that the therapy produced.[19]

Holloway M. 2003 et al. the functional changes in the brain that underlie the chronically maintained responses to training whether in healthy or in diseased adults are referred to by the term neuroplasticity (or neural plasticity or brain plasticity). It has generally been assumed that such changes involve physiological or microscopic structural alteration of neurons or neuronal circuits such as efficiency of synaptic connections or the growth of new synapses, without gross structural changes. However it would be incorrect to assume that such structural changes do not occur on macroscopic scale.[23]

The reason why mCIMT may also be used effectively in mild disability post-stroke cases.

Although the present study through its statistical analysis does not show much improvement in mild disability post-stroke cases which may be due to small sample size but on the basis of present study it can be assumed that if mCIMT showed improvement in moderate and severe cases then it may also show improvement in mild disability post-stroke as well. Future randomized control trials with more sample size (at least 30 patients) of mild disability post-stroke would be needed to get significant findings regarding effectiveness of mCIMT in mild post-stroke disability.

Limitations of present study are

1. The number of mild disability post-stroke cases was less.
2. The therapy sessions taken by patients before involving in CIMT therapy must be known.
3. Less overall duration of study.
4. Less sample size.
5. Limited parameters were taken.
6. No long-term follow up was taken after 3 weeks.
7. Measurements were taken manually which may produce human errors.

Future recommendations are

1. Increase overall duration of study at least 1 year.
2. Increase sample size at least 30 patients in

each category (mild, moderate and severe disability post-stroke)

3. Increase number of parameters, which can be: can add motor activity log or wolf motor scales and any functional scale for upper limb.
4. Follow ups should be taken to assess long-term effects.
5. Measurements can also incorporate any automatic mechanical device if possible to avoid human errors.

Conclusion

This study concluded that the patients from moderate to severe post-stroke disability improved better than the mild sever stroke patients so in this case the hypothesis can be rejected and it is accepted that CIMT can be used more beneficially in moderate and severe disability post-stroke than the mild post-stroke disability.

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