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Research Article

Effectiveness of distributed form of constraint induced movement therapy to improve functional outcome in chronic hemiparesis patients

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ABSTRACT

Background: Upper limb hemiparesis is among the most common deficits after stroke that leads to disability. Learned nonuse develops due to over-reliance on the less affected limb for the functional activities. However for many stroke patients, participation in a traditional, more intense CIMT may be problematic, given the required practice intensity and the duration of the restraint schedule. So it is necessary to evaluate the effects of distributed form of Constraint Induced Movement Therapy (dCIMT) in improving functional outcome and quality of life in patients with chronic hemiparesis.
Methods: 36 hemiplegic patients following stroke were included. The experimental group was given dCIMT for 5sessions/week for 4 consecutive weeks in addition to conventional therapy while the control group received only conventional therapy. The outcome measures were motor activity log, wolf motor functional test and nine hole peg test.
Results: The results of within group analysis for both the experimental group (Group-A) and control group B showed highly significant improvement on all the 3 outcome measures with P <0.0001.But the difference in the improvement of group-A compared to group-B was highly significant on the MAL and NHPT (P <0.0001) whereas it was not significant for WMFT performance score but highly significant for WMFT duration (U=23).
Conclusion: dCIMT is an effective measure in improving the upper extremity motor function in terms of the quality and amount of use & speed and co- ordination. Thus improves the functional level and the quality of life of the patients with chronic stroke.

Keywords: Chronic stroke, CIMT, Quality of life, Upper extremity functions

INTRODUCTION

Stroke is the sudden loss of neurological function caused by the interruption of the blood flow to the brain.[1] Hemiparesis is among the most common deficits after stroke, leading in many cases to disability and permanent dependency on community care. In the last few decades there have been a rise in the incidence and prevalence of stroke in India, attributable to increasing life span, urbanization, and better survival, and the rates are now matching western figures.[2] The incidence of stroke increases dramatically with age doubling every decade after 55 years of age. The age adjusted prevalence rate of stroke was between 250-350/100000.[3] Upper-limb hemiparesis, is particularly problematic given its impact on Activities of Daily Living (ADLs).Due to its impact on ability to perform Activities of Daily Living (ADLs), interventions to reduce upper limb impairment are at priority.

Rehabilitation efforts to restore upper limb function have been substantially less successful than interventions to improve lower limb function and ambulation, with most survivors unable to use their affected arm for months poststroke.[4-6] Studies of laboratory animals and human stroke survivors support the theory that potential motor recovery is limited by a learned overreliance on the unaffected limbs.[7-9] Immediately after brain injury, flaccidity in limb muscles contra lateral to the brain lesion limits functional use of those limbs. Because motor function in the opposite arm and leg is unaffected, most stroke survivors compensate by relying exclusively on the unaffected limbs to perform tasks. This theory of learned nonuse may explain why upper limb recovery lags behind lower limb recovery.[10]

CI Therapy is derived from basic behavioral neuroscience research with non-human primates conducted by E.T. and coworkers. When a single forelimb is deafferented in a monkey, the animal does not make use of it in the free situation.[11-13] However, Taub and co-workers found that monkeys can be induced to use the deafferented limb by restricting movement of the intact limb for several days. A useless limb is thereby converted into a limb capable of extensive movement.[14] In Constraint-Induced Movement Therapy (CIMT); physical constraint to the unaffected upper limb is provided in an effort to reverse the effects of learned nonuse by the affected arm. CIMT is a rehabilitation approach that is designed to reduce incapacitating motor deficits of the Upper Limbs (ULs) in patients after neurological injury and increase their functional independence. Gains in motor function following CIMT have been demonstrated in patients following stroke and these changes are associated with changes in brain organization as evidenced by functional Magnetic Resonance Imaging (fMRI).[15]

Evidence from a number of studies suggests that the size of the cortical representation of a body part in humans depends on the amount of use of that body part. Five recent focal trans-cranial magnetic stimulation, neuro-electric source 3 imaging, and electroencephalograph readiness-potential studies with humans conducted by four groups of investigators indicate that CIMT produces a substantial change in brain organization and function correlative with its large clinical effect.[16,17] In CIMT researchers have restrained the unaffected arms of chronic patients with CVA for 90% of waking hours each day for 2 weeks while having patients perform purposeful activities with the affected arm for 6 hours/day on 10 consecutive weekdays. The results of these studies, a randomized, controlled study and a case study suggest that this Constraint Induced Movement Therapy (CIMT) overcomes - learned nonuse, has been shown to be a promising training method for enhancing the reuse of the more-affected hand in patients with chronic stroke. The intervention consists of 2 components: (1) intensive motor training of the more-affected upper extremity by a procedure termed - shaping and other behavioral methods for 6 hours a day for 10 consecutive weekdays and (2) motor restriction of the less-affected hand for the full 14 days of the intervention.[18]

Although efficacious, findings from a survey, measuring patients‘ and therapists‘ opinions of CIMT suggest that its clinical implementation is limited.[19] Six hours a day of intensive, individual training is difficult to arrange in an Indian rehabilitation clinic. With regard to the practice component, they noted that some 4 clinics may lack adequate resources or personnel to engage patients for 6 hours per day. Also stroke patients with poorer physical condition have less capacity for demanding activities, a 6-hour a day training schedule may be too strenuous for them. The demanding nature of behavioral intervention techniques can be a major concern in stroke patients; it may also act against the therapy’s effectiveness, when a patient is pushed beyond his/her endurance limits and becomes fatigued.[20]

It is much easier to perform intensive motor training for 3 hours a day for 20 (rather than 10) days. The total amount of training would be similar in both approaches, but the difference in the schedule of delivery of therapy is not negligible; therefore, the question whether the distributed version is also effective in improving upper limb function in chronic stroke. Hence the need of this study is to find the effectiveness of distributed form of CIMT (dCIMT) in chronic stroke patients in the Indian population.

METHODS

Subjects with chronic Stroke coming to OPD of neurology department of SBB college of physiotherapy, V.S. general hospital, Ahmedabad, and Shri Maniben Ayurvedic hospital Ahmedabad, Gujarat were screened for study. Study is non-blinded quasi experimental study 36 subjects with both genders according to convenient sampling, those who were following into inclusion criteria were recruited for the study. Patients with stroke >6 months, patients walking without assistive device having minimal spasticity at hand and those who were able to do active extension of at least 20 degrees at wrist and 10 degrees of each finger of the more affected hand were included in the study. Patients with serious balance problem, cognitive problem and with aphasia were excluded. Nature and purpose of the study was explained to the patients and written consent was taken from the patient prior to the study entry.

After the evaluation patients were divided into two groups: group A - experimental group (were given dCIMT plus conventional therapy) group B - control group (were given conventional therapy).

Group A was given distributed form of constraint induced movement therapy in addition to the conventional therapy. In this resting splint was given to the less affected arm for 90% of the waking hours a day, including the training session. Patients were given intensive motor training for 3 hours a day for 20 consecutive weekdays. (Total 20 sessions) One hour of the training session was given at the clinic and 2 hours home program was given. Training session involved warm up session including mild stretching exercises followed by strengthening exercises. Then repetitive performance of the daily/functional tasks as per the needs of the patient was given. A tailor made home program was also given to each patient depending on the needs of the patient to be performed twice a day. (Each session of one hour) As the patients were restricted at home also, logs were kept to document restrictive device use time, as well as activities performed during restrictive hours. Group B was given only conventional therapy regularly for one month.

Figure 1: Patient's performing activities during the training session of dCIMT.

Outcome measures used in this study were:

***Motor activity log (MAL)*[21]**

The MAL is a semi structured interview measuring how people use their more affected limbs for ADL tasks in home. It consists of a 6-point Amount Of Use scale (AOU) to rate how much the patient is using the affected arm and a 6-point - Quality Of Movement (QOM) scale to rate how well the patient is using it. Tasks include classic ADLs such as brushing teeth, buttoning a shirt or blouse, and eating with a fork or spoon.

***WMFT*[22]**

The WMFT was developed by Wolf et.al. to examine and measure the effect of CIMT for survivors of stroke and traumatic brain injury. It is sensitive to the level of motor functioning characteristics in patients with mild to moderate stroke. The WMFT is an instrument with high inter-rater reliability, internal consistency, and test- retest reliability. It consists 15 items which measures the performance and time of the functional tasks in a laboratory condition. The subjects were asked to complete these tasks as fast as they could with the more affected limb. If a subject was unable to complete an item within 2 minutes, the attempt was stopped and a performance time of over 120 seconds assigned.

***Nine hole peg test*[23]**

The nine hole peg test has high reliability and validity and is used to measure the dexterity of the finger. In this test the subjects were asked to remove and keep the pegs to the peg board as fast as they can with the more affected limb. The placement of the pegs was kept at the same place for all the patients.

Data was collected from both the groups before and after the intervention and statistical Inferences' were done using SPSS 16 software.

RESULTS

The study was carried on 36 stroke patients divided into two groups. The subjects were divided into two groups:

Group A - Experimental group (were given dCIMT)

Group B - Control group (were given conventional therapy)

All the subjects completed the program satisfactorily.

All the tests and calculations were performed using graph pad prism 5.03 version. Level of significance was kept at 5%.

Table 1 show the gender distribution of the 36 subjects who participated in the study. Group A had 10 males and 8 females and group B had 11 males and 7 females. Table 2 displays the age distribution among the 36 subjects. The mean age of the 18 patients of group A is 51.11 with the standard deviation 8.54.the mean age of the 18 patients in group B was 55.22 with the standard deviation of 6.17. No significant statistical difference was found among the age distribution of the two groups. Table 3 shows the duration of stroke. The mean duration from the onset of subjects in group A is 13.38 months with the SD 6.34 and that of group B is 15.11 months with the SD 6.24 suggesting of no significant difference among the duration since the onset of stroke between the two groups.

Table 1: Gender distribution of the patients.

Gender	Group A	Group B	Total
Male	10	11	18
Female	8	7	18

Table 2: Age distribution of the patients.

Age group	Mean ± SD
Group A	51.11 ± 8.54
Group B	55.22 ± 6.17

Table 3: Duration since the onset of stroke.

Duration (months)	Mean ± SD
Group A	13.38 ± 6.34
Group B	15.11 ± 6.24

Mean difference of the WMFT score and WMFT duration before and after intervention in group A: Wilcoxon signed rank test was applied to WMFT performance score the W-value was - 171.00 and the P value was 0.0002 showing significant difference between the pre and post intervention values. Paired t-test was applied to WMFT Duration showing P = 0.017 and t = 9.971 showing highly significant difference between the pre and post intervention values. Table 5 shows the mean and the SD of WMFT Duration. Table 6 gives the mean and the SD of the duration of the Nine Hole Peg Test before and after the intervention. Paired t-test was used to evaluate the difference between pre and post intervention values, the p-value was 0.006 and the t = 10.81 with df of 14 showing highly significant improvement in the nine hole peg test. Paired t-test was applied to compare the data of the QOM scale, the t-value was 9.682 with the df of 17 showing significant improvement. Paired t- test was applied to compare the pre and post intervention data, which shows significant improvement in the Amount Of Use (AOU).

Table 4: Mean and SD of WMFT performance score.

WMFT score	Mean ± SD	W value	P value
Pre-test	41.55 ± 4.003	-171.00	0.0002
Post-test	48.8 ± 4.676		

Table 5: Mean and SD of WMFT duration.

WMFT duration	Mean ± SD	W value	P value
Pre-test	91.60 ± 24.93	9.971	0.017
Post-test	71.74 ± 22.56		

Table 6: Mean and SD of nine hole peg test results.

Nine hole peg test	Mean ± SD	t-value
Pre-test	67.57 ± 21.43	10.81
Post-test	48.33 ± 18.55	

Table 7 & 8 shows the mean and the SD of the WMFT performance score and WMFT duration respectively for the Pre-test and Post-test values for group B. Paired t-test was applied to both the components of WMFT which showed significant improvement before and after the treatment. Table 9 gives the mean and the SD of the duration of the nine hole peg test before and after the intervention. The data was converted into parametric form by taking the log(y) then Paired t-test was used to evaluate the difference between pre and post intervention values, the p-value was P <0.0001 and the t = 8.29 with df of 17 showing significant improvement in the nine hole peg test. Paired t- test was applied to both the scales to find effect of the conventional therapy. The df was kept at 17 and the t-value was 9.649 and 10.60 for the QOM and AOU respectively suggesting of significant improvement.

Table 7: Mean and SD of WMFT performance score.

WMFT score	Mean ± SD	t-value	P value
Pre-test	41.66 ± 4.91	8.609	<0.0001
Post-test	46.61 ± 5.47		

Table 8: Mean and SD of WMFT duration.

WMFT duration	Mean ± SD	t-value	P value
Pre-test	93.43 ± 46.83	9.379	0.001
Post-test	81.48 ± 39.76		

Table 9: Mean and SD of nine hole peg test results.

Nine hole peg test	Mean ± SD	t-value
Pre-test	80.17 ± 61.40	8.29
Post-test	71.18 ± 60.16	

Table 10 gives the mean and the SD of the difference between the WMFT performance score and the WMFT duration among the experimental and the control group. Unpaired t-test was applied to the WMFT performance score, the df was kept at 35 which gave the t-value of 2.75 suggesting that no significant difference exists among the performance in the two groups. Mann Whitney test was applied to the WMFT duration scores which gave the value U=23 suggesting of extremely significant difference among the two groups. Table 11 gives the mean and SD of the difference in the duration pre and post intervention of the nine hole peg test. Mann Whitney test was applied to compare the difference between the results of the two groups which gave the U-Value of 28 suggesting of extremely significant difference among the two. Table 112 gives the mean and SD of the difference in the scores pre and post intervention of QOM and AOU scales of the motor activity log. Unpaired t-test was applied to compare the difference between the results of the two groups , df was kept at 34 which gave t = 3.807 (P = 0.0006) and t = 7.608 (P <0.0001) for QOM and AOU scales respectively, suggesting significant difference exits for the QOM scale whereas extremely significant difference exists in the AOU score.

Table 10: Mean and SD of WMFT of group A & B.

	Mean ± SD (Experimental)	Mean ± SD (Control)	t-value / U-value
WMFT score	7.33 ± 2.76	4.94 ± 2.43	t = 2.75
WMFT duration	19.86 ± 8.45	8.80 ± 3.98	U = 23

Table 11: Mean and SD of NHPT.

	Mean ± SD (Experimental)	Mean ± SD (Control)	U-value
Nine hole peg test	19.24 ± 7.55	8.99 ± 331	28

Table 12: Mean and SD of AOU and QOM of group A and group B.

	Mean ± SD (Experimental)	Mean ± SD (Control)	t-value
QOM	10.38 ± 4.55	5.72 ± 2.51	t = 3.807
AOU	20.55 ± 7.18	6.77 ± 2.71	t = 7.60

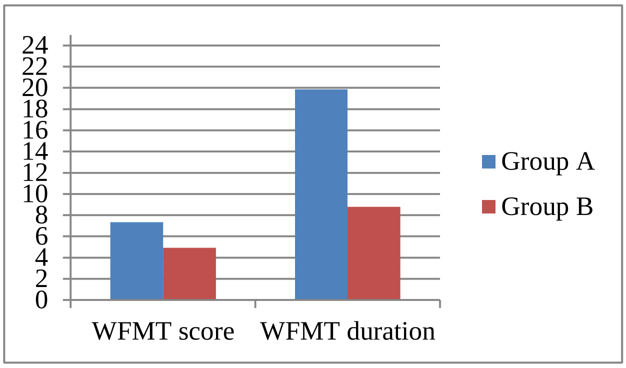

Figure 2: Mean of the WMFT score and WMFT duration before and after intervention in group A and group B.

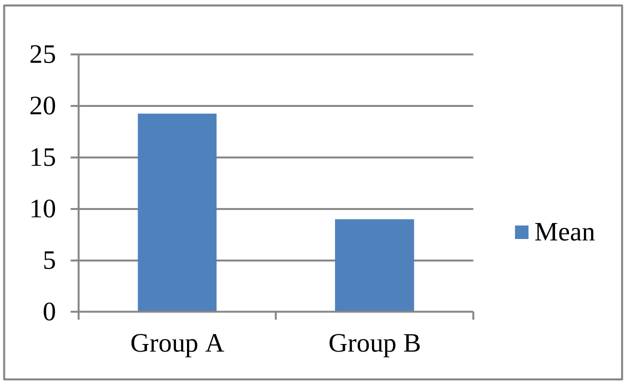

Figure 3: Mean of NHPT of group A & B.

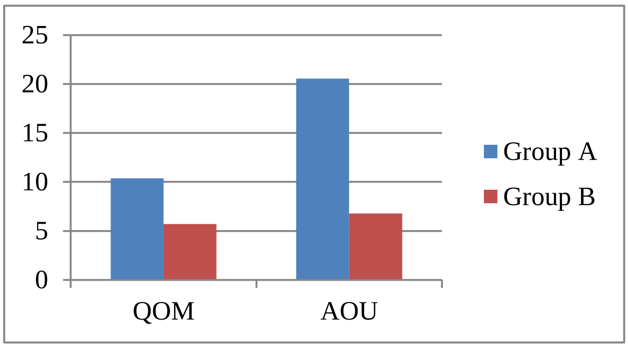

Figure 4: Mean of AOU and QOM of group A and group B.

DISCUSSION

Many studies have already reported that CIMT is an effective treatment with restriction of the intact upper limb during training.[24-26] However for many stroke patients, participation in a traditional, more intense CIMT may be problematic, given the required practice intensity and the duration of the restraint schedule.[19] In the present study, we examined the efficacy of distributed form of constraint induced movement therapy in improving use and function of more affected upper limbs in chronic stroke patients.

Before intervention, patients only occasionally used their affected arms for ADLs. These reported behaviors were corroborated by highly significant scores of the difference in the motor activity log scales QOM and AOU before and after the intervention with the t-values of t = 9.682 for QOM and t = 16.17 for AOU which suggests increased use of the more affected limb for ADLs of the dCIMT group (Table 7 & 8, Figure 4). Although the control group also showed improvement on both the MAL scales but the difference in the improvement on the QOM scale of the dCIMT group was significant and that on AOU scale was highly significant with t = 7.60 (Table 12, Figure 4) which suggests that dCIMT can be effective method of treatment of the learned non-use.

The above findings can be explained by the work done by Stephen J. Page, Sue Ann Sisto et al. in 2004,[19] which concluded that mCIMT can be an efficacious method for improving function and use of the more affected arms of chronic stroke patients. The study suggested that repeated, task-specific practice is critical to reacquisition of function, whereas practice schedule intensity is less critical. The above changes in affected arm use were manifested in behavioral changes. Patients who exhibited stable motor deficits before intervention, they exhibited motor improvements after intervention. Those who exhibited larger AOU changes also exhibited greater motor changes.[26] The dCIMT subjects reported that they were attempting ADLs with the more affected limb that they had not attempted since onset of their strokes, including using the limb for writing, eating, and/or grooming. dCIMT patients realized that they were capable of doing more with their affected limbs than previously thought, and often attempted additional ADLs.

Subjects in the dCIMT group also displayed substantial improvements on the WMFT between pretesting and post testing sessions, both in terms of rating of movement and time taken to complete the movement. In contrast, subjects in the control group also displayed little improvement in terms of rate of performance. But the difference between the two groups was extremely significant with U = 23, whereas difference between the two groups for performance rating was not significant.

Shaping is a commonly used operant conditioning method in which a behavioral (in this case - movement) objective is approached in small steps of progressively increasing difficulty. The participant is rewarded with enthusiastic approval for improvement, but never blamed (punished) for failure. In CIMT, a basic principle is to keep extending motor capacity in small increment beyond the performance level already achieved.[27] The more difficult tasks (such as stack checkers, turnkey in lock, or lift basket) need more hand control and strength. This phenomenon might indicate that the shaping program has more effect on the complex and functional tasks. Similar research also showed that their m-CIMT participation elicited functional changes.[27]

After shaping treatment, stroke patients might get more motor gains and better independent activities of daily life.[28] After stroke the size of the cortical representation of the affected hand is known to decrease,[29,30] possibly due to limb nonuse.[31] However, during task-specific protocols in which the affected arm is repetitively and functionally used, the size of the cortical areas representing the limb increases.[32]Several studies have used trans cranial magnetic stimulation to show that CIMT produces an increased excitability of the primary motor cortex and an enlargement of the cortical hand representation in the primary motor cortex in humans with stroke.[15,26,32] Thus increasing affected limb use can lead to increased cortical representation of the affected extremity. dCIMT increases affected limb use and function. Also shaping and behavioral changes occurs in the subjects in the present study using dCIMT which are similar results as compared to the studies with acute, sub-acute, and chronic patients with stroke, in which mCIMT appeared to induce cortical reorganization, as measured by fMRI. The Cortical reorganization was positively related to degree of increase in affected arm use and ability.[27] With regard to these findings we can predict that cortical reorganization would have occurred in subjects of the present study.

The present study indicates that dCIMT has a pronounced and significant effect on improving the motor ability in chronic hemiplegia. The patients' functional movement capabilities improved so that new tasks of daily living could be performed outside the laboratory and in the home environment.[28]

After treatment, statistical analysis of objective outcome measures showed a significant improvement in all the variables (AOU, QOM, WMFT, and NHPT). Pre-post comparison of WMFT and the NHPT measurements revealed that all patients were able to perform movements with their affected hand faster and with more dexterity after therapy (As measured by NHPT[23]). Dexterous hands are important for most Activities of Daily Living (ADLs), such as food preparation and grooming. Loss of hand dexterity might limit ADL performance and social participation and thus reduce quality of life in patients with stroke. Also QOM scale of the Motor Activity Log and WMFT are related with the hand function related quality of life.[34] Keh-chung Lin et al. suggests that self-perceived actual use (MAL-AOU) and that fine manual dexterity is an important component that determines the hand function aspect of quality of life after stroke. Thus we can predict that dCIMT improves hand function related quality of life.[35]

Impairment of upper extremity function after stroke results in significant limitations in daily function and has been demonstrated to negatively impact health related quality of life. In the present study statistically significant improvement is seen on the MAL & WMFT scale. The affected hand performance increased significantly for AOU & QOM and WMFT. These findings indicate that the affected hand was used more often and with better quality for ADLs; thus, the improvements induced by training in the laboratory transferred into the home environment. The finding that dCIMT increases affected limb use was consistent with those reported in previous mCIMT studies.[27]

The result of this study indicates that dCIMT treatment is easily accepted and has a better result than traditional rehabilitation programs.

CONCLUSION

Study concluded that the distributed form of constraint induced movement therapy can lead to shaping and behavioral changes which leads to improvement in speed and dexterity that leads to reverse learned nonuse so can be an effective form of treatment for the chronic stroke patients in the Indian population. Study is limited in small sample size; long term effect of dCIMT was not seen. Study was done only for chronic stroke and those who have regained wrist movements were included in the study.

Future study

Future study with long term follow up considering acute and sub-acute subjects should be done. Study comparing dCIMT versus CIMT should be done and fMRI can be done to find cortical reorganization with dCIMT.

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