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**Research Article**

# Constraint-Induced Movement Therapy in Compared to Traditional Therapy in Chronic Post-stroke patients

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ABSTRACT

**Introduction:** Constraint-induced movement therapy (CIMT) forces the use of the affected side by restraining the unaffected side. The purpose of this article is to explore the changes of motor and functional performance after modified CIMT (mCIMT) in comparison with traditional rehabilitation (TR) in chronic post-stroke patients.

**Material and Methods:** A total of 12 patients randomly assigned into two treatment groups. Six patients in the mCIMT group received intensive training in a more affected limb for 2 hours daily, 5 days/week using shaping method over a period of 21 days. Participants less affected limb were restrained in arm - hand splint with a target of wearing it for 5 hours daily. The patients in TR group received bimanual and unilateral activities, stretching, strengthening and coordination exercises of the impaired side, tone modification and coordination exercises of the affected side. The focus was to increase independence in activities of daily living activities using affected side. The motor activity log (MAL), wolf motor function test (WMFT), and modified ashworth scale were measured at pre-test (1 day before training), post-test (1 day after training) and follow-up in 3 weeks after training.

**Results:** The Friedman test found significant differences between pre-test, post-test, and follow-up in MAL and WMFT in mCIMT group. Furthermore, mCIMT group showed significant decreased spasticity ($P = 0.030$) that measured by ash worth scale. The effect sizes between post-test and pre-test in the above-mentioned outcome measures were moderate to large in mCIMT, ranging from 0.3 to 0.76, but in TR group the effect size were small, ranging from 0 to 0.2.

**Conclusion:** Therefore, it seems that the mCIMT treatment was more effective than TR in improving some parameters.

**Keywords:** Constraint-induced movement therapy; Motor activity log; Stroke; Wolf motor function test

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## Introduction

Improvement of upper extremity (UE) function is a major problem for survivors of stroke, only 5% of whom regain full function (1). However, there is evidence that motor rehabilitation of chronic stroke patients remains successful several months or years after the acute stroke (2).

Over time, if the functional use of the affected UE is not regained, adaptive methods, and equipment can compensate for the lack of function in the affected UE. However, while compensatory strategies will increase efficiency, lack of use of the affected UE fails to activate the neuronal connections and can lead to “learned non-use” of the arm (3).

There are controversies about evidence of the effectiveness of exercise therapies on arm function (4-6). However, these authors suggested that more intensive therapies might be beneficial.

There is strong evidence that repetitive task-specific training techniques improve measures of UE function.

Constraint-induced movement therapy (CIMT) or modified CIMT (mCIMT) involves constraining the unaffected UE of a hemiparetic stroke patient while the patient undergoes extensive motor training has been shown to be effective in inducing central nervous system reorganization and motor recovery.

Fleet et al. (7) indicated by systematic review that the mCIMT is an effective intervention in UE impairment in post-stroke patients.

Van Delden et al. (8) in a systematic review reported that unilateral (CIMT) and bilateral training are similarly effective. However, intervention success may depend on the severity of upper limb paresis and time of intervention post-stroke.

van der Lee et al. (9) have compared CI therapy to treatment emphasizing bimanual activities. Their results showed that 1 week after the last treatment session, the change within the CI therapy group was significantly different compared with the group undergoing bimanual training for action research arm test and the motor activity log (MAL) amount of use (AOU) score.

Suputtitada et al. (10) reported that CIMT may be an effective technique of improving motor activity and exhibiting learned non-use. In this study, control group received bimanual-upper-extremity training by conservative neuro-developmental technique without restrained unaffected upper extremities for 2 weeks.

Page et al. (11) concluded that mCIMT may be an effective method of improving function and the use of the more affected arms of chronic stroke patients than regular therapy or no therapy.

In a systematic review of randomized controlled trials on CIMT following stroke, Hakkennes and Keating (12) stated that results indicate that CIMT may improve upper limb function following stroke for some patients when compared to alternative or no treatment.

The findings of Suputtitada et al. (2004), Page et al. (2004) are in agreement with the observations of Hakkennes and Keating (2005) and Shi et al. (2011).

Shi (2011) provided fairly strong evidence that mCIMT could reduce the level of disability, improve the ability to use the paretic UE, and enhance spontaneity during movement time than traditional treatment.

However, Fleet et al. stated (2014), the most of physiotherapists used of traditional therapy such as NDT approach, bimanual exercise, strengthening, stretching, and compensatory techniques (13).

In other wise, these existing studies have only compared the effectiveness of CIMT to compensatory or bimanual training techniques and or no treatment. There are no techniques designed to practice retraining isolated active movement in the hemiplegic arm (14).

For this reason, we decided to evaluate the effect of the mCIMT method in compared to the traditional rehabilitation (TR) over hand movements in stroke patients, but we focused on active exercise and using of affected upper limb in activity daily living in TR.

The aim of this study was to investigate the effectiveness of mCIMT in chronic post-stroke patients compared to standard care in 3 weeks treatment. Our primary and secondary outcomes were the arm - hand function assessed by MAL and wolf motor function test (WMFT) and spasticity by modified ashworth scale (MAS) in mCIMT program compared to standard care (active rehabilitation). Follow-up was carried out after 21 days.

The MAL (0-5 point scale) is a self-assessment questionnaire capturing quality of movement (QOM) and AOU of the more affected arm in 20 common and important activities of daily living (ADL). The MAL is a valid and reliable scale of arm use and movement quality in real-world settings (15).

The WMFT consists of 14 motor tasks and examines distal and proximal musculature function of the UE. The WMFT is a measure of laboratory time and strength-based ability and QOM (functional ability). WMFT is a reliable tool with a high inter-rater reliability scores (16).

Spasticity was assessed by MAS in shoulder adductor, elbow flexor, and wrist flexor muscles. The MAS was performed by passive movement of a joint through its range of motion at a standard speed and rating the resistance of stretched muscles on a 6-point scale. That is widely accepted as a clinical tool appropriate to assess spasticity (17).

## Materials and methods

This study was a single-blind randomized controlled trial. The patients blinded.

About 16 patients participated in this study. The patients who demonstrate at least 20° of wrist extension and 10° of finger extension with minimal sensory or cognitive deficits.

This was a between-subjects control intervention study. Outcome measures were taken on three occasions: pre-test (the day before training), post-test (the day after), and follow-up (3 weeks later).

Patients in mCIMT group received intensive training of affected limb 2 hours daily, 3 days/week, for 3 weeks and restraining the less affected hand for 5 hours at home (18) with shaping method.

Each mCIMT session started with stretching exercises, correct handling for control of spasticity, weight bearing on hand, shaking and reflex-inhibiting pattern to normalize muscle tone in the affected limb for 10 minutes of therapy. Then, patient receives intensive treatment of the affected arm consisted on a variety of task-oriented and repetitive training.

The patients were encouraged to wear the sling at home for 5 hours daily (18) with the aim of improving the learned skills in daily living activities.

Repetitive and task-oriented training, fine motor training, muscle strength and stretch were carried out according to shaping method and functional task performed. Shaping was designed to produce intensive use of the more affected extremity and to improve the QOM (19).

The practice program concentrated on the affected upper limb usage in functional tasks was chosen by the patient. Three or four tasks including hair brushing, writing, throwing a ball, opening, and closing bottles having food with fork and spoon were done through shaping and functional tasks. Each participant wore an arm-hand sling on the less-affected side during each session; they were encouraged to wear it during non-treatment time as well with the aim being to achieve 5 hours of use per week day. Home skill assignments were discussed with participants in each session and documented in a home diary. The use of the home assignment is important as it enables participants to generalize the skills learned to their real-life activities. Group activities, such as meal preparation, were used to motivate participants' functional arm use.

The second group similar to the CIMT group was conducted for approximately 2 hours/day, 3 days/week, and over a period of 21-day. As with the CIMT condition, each therapist, the same ones who treated the CIMT patients, treated each patient for an equal amount of time. Initially, patients attempted simple movements and subsequently complex movements with affected limb. Multiple repetitions of the same movement help in motor relearning. When some active movements returned to the affected limb, the patient should repeatedly perform them. The use of arm and hand in simple tasks such as dressing, self-feeding, and grooming is the best way to facilitate motor recovery. Therefore, the patients in the second group should be performed these tasks repeatedly. This group received UE strength and range of motion, and traditional positioning. Subjects also participated in a circuit-training program allowing patients to perform bilateral self-range of motion and functional activities in a supervised setting. The second group similar to the CIMT group was conducted for approximately Home skill assignments were discussed with participants in each session and documented in a home diary. The use of the home assignment is important as it enables participants to generalize the skills learned to their real-life activities. Group activities, such as meal preparation, were used to motivate participants' functional arm use. They should do all exercise at home without fatigue with focus on affected limb evaluated.

This study was approved by the ethical Committee of Tehran University of Medical Sciences.

***Specific primary and secondary outcome with follow-up***

Three outcome measures including MAL, WMFT, and MAS were carried out 3 times: pre-test (1 day before treatment), post-test (1 day after treatment, because the patients, immediately after the end of treatment were exhausted and did not have the necessary cooperation), and follow-up (3 weeks after treatment).

A total of 25 patients were referred to the ward, among them 16 patients fulfilled the inclusion criteria and were randomly assigned into two groups using sequentially numbered randomization (mCIMT or TR). The patients were blind to the kind of treatment.

All statistical analyses were conducted using the Statistical Package for the Social Sciences (version 17.0; SPSS Inc. Corp, Chicago, IL, USA). The significance level was set at 0.05 for all tests.

The Friedman test with multiple comparisons was used to analyze data between pre-test, post-test, and follow-up to reveal any significant changes. The standardized mean difference effect size was used to contrast the post-test and pre-test results and show the magnitude and direction of the relationship (20).

To detect significant differences between the two groups (mCIMT vs. TR), The Mann–Whitney U-test was used. Data collection and analysis performed by blinded physiotherapist.

## Results

Around 25 patients with cerebrovascular accident (CVA) who referred in this study. 16 subjects were included based on the inclusion criteria. These patients were randomly assigned into two treatment groups. Four patients (two patients in each group) of 16 patients excluded: two patients had a new stroke attack and two patients did not attend in all treatment sessions.

The research was carried out on twelve patients [(6 patients with 50.80 ± 9.07 years, time of CVA 3.6 ± 4.6, side of hemiparesis $3_{left}$ $3_{right}$, 2 women 4 men, dominant side left/right: 1.5 in mCIMT) and 6 patients in standard care; age = 52.8 ± 13.4 years, time of CVA 3.6 ± 3.1, side of hemiparesis $1_{left}$ $5_{right}$, 1 women 5 men, dominant side left/right: 0.6)].

The Mann–Whitney U-test did not show any significant differences between two groups at the baseline in primary and secondary outcomes.

The Friedman test was used to analyze data between pre-test, post-test, and follow-up (Table 1). Significant differences were found in the QOM ($F = 11.56$, $P = 0.003$), AOU ($F = 11.56$, $P = 0.003$) and TWMFT subscore ($F = 7.54$, $P = 0.006$) in mCIMT group.

Moreover, in mCIMT group significant differences were found in motor function WMFT subscore ($F = 9.4$, $P = 0.009$) and improvement of shoulder adduction spasticity ($F = 8$, $P = 0.010$), Shoulder flex ($F = 6.5$, $P = 0.030$) and wrist flex ($F = 6$, $P = 0.050$) measured by MAS in mCIMT group.

In TR group, only significant difference indicated in TWMFT subscore ($F = 10.35$, $P = 0.006$ in TR group).

The Mann–Whitney test, demonstrated significant differences in AOU and QOM immediately after treatment and QOM in follow-up in favor of mCIMT group ($P = 0.009$).

**Table 1.** Results of the Friedman test on the outcome measures at pre-test, post-test, and follow-up

| Group | Outcome measure | Pre-test (1) | Post-test (2) | Effect-size | Follow (3) | F | P |
|---|---|---|---|---|---|---|---|
| mCIMT | QOM | 0.61 ± 0.43 | 1.85 ± 0.59 | 0.77 | 2.33 ± 0.78 | 11.56 | 0.003 |
| | AOU | 0.56 ± 0.42 | 1.71 ± 0.55 | 0.76 | 2.30 ± 0.87 | 11.56 | 0.003 |
| | TWMFT | 12.16 ± 3.20 | 9.48 ± 1.58 | 0.47 | 6.83 ± 1.32 | 7 | 0.006 |
| | WMFT | 2.8 ± 1.3 | 4.00 ± 0.74 | 0.49 | 4.40 ± 0.97 | 9.4 | 0.009 |
| | Ash add | 0.83 ± 0.75 | 0.17 ± 0.41 | 0.48 | 0.17 ± 0.41 | 8 | 0.010 |
| | Ash fle | 1.3 ± 0.8 | 0.83 ± 0.75 | 0.3 | 0.60 ± 0.55 | 6.5 | 0.030 |
| | Ash wrist flex | 1.33 ± 1.03 | 0.50 ± 0.55 | 0.45 | 0.50 ± 0.55 | 6 | 0.050 |
| TR | QOM | 0.63 ± 0.80 | 0.93 ± 0.78 | 0.18 | 1.03 ± 0.66 | 3.52 | 0.170 |
| | AOU | 0.56 ± 0.55 | 0.65 ± 0.53 | 0.08 | 0.75 ± 0.49 | 0.8 | 0.600 |
| | TWMFT | 12.58 ± 5.20 | 10.55 ± 4.20 | 0.2 | 9.60 ± 3.56 | 10.35 | 0.006 |
| | WMFT | 3.20 ± 1.66 | 3.32 ± 1.53 | 0.03 | 3.41 ± 1.63 | 1.4 | 0.480 |
| | Ash add | 0.67 ± 1.03 | 0.50 ± 0.84 | | 0.50 ± 0.84 | 2 | 3.000 |
| | Ash fle | 0.67 ± 0.82 | 0.67 ± 1.03 | 0 | 0.8 ± 1.1 | 0 | 1.000 |
| | Ash wrist flex | 1.2 ± 1.1 | 1.00 ± 0.71 | 0.1 | 1.00 ± 0.71 | 2 | 0.300 |

Values are means ± SD; pre-test, one day before intervention; post-test, 1 day after intervention; follow-up, 4 weeks after intervention. *P < 0.050. QOM: Quality of movement, AOU: Amount of use, WMFT: Wolf motor function test, Ash: Ashworth, mCIMT: Modified constraint-induced movement therapy, TR: Traditional rehabilitation, SD: Standard deviation

The effect sizes between post-test and pre-test in the above-mentioned outcome measures were moderate to large in mCIMT, ranging from 0.3 to 0.76, but in TR group the effect size were small, ranging from 0 to 0.2. All the gains in WMFT, QOM and AOU were maintained during the 21 days following the intervention, since no significant change was found between post-test and the 3 weeks follow-up. Only in mCIMT group QOM, AOU and time score of WMFT showed a significant difference between post-test and 3 weeks follow-up.

Table 1 shows the mean and standard deviations in QOM and AOU test scores, speed and functional movement test scores that measured by WMFT and MAS in shoulder adduction, at pre-test, post-test, and follow-up.

## Discussion

The results of this study showed that QOM and AOU (assessed by MAL) increased between the pre-test and post-test, and follow-up in both groups, but only in mCIMT group these differences was significant.

The speed of functional movement that was measured by time score of WMFT increased significantly between the pre-test and post-test, and follow-up in both groups.

The comparison of between two groups showed significant difference in QOM and AOU test scores after treatment and QOM in follow-up in favor of mCIMT group.

Before intervention, the subjects occasionally used their more affected arms for ADL tasks. The substantial improvements of MAL scores after treatment showed that the patients were more willing to engage their affected upper extremities and produced enhanced movement. Immediately after the intervention subjects in both groups tried to use their more affected limbs in daily activities more than before. These discrepancies were greater and significant in mCIMT groups. More than 1 point change on AOU scale in mCIMT group shows increased use of the subject's affected limb in ADL.

This MAL changes, particularly in terms of AOU scale scores, were comparable with the results of previous mCIMT studies (15, 21-23). The patients in the TR group reported they attempted to use the affected arms, but sometimes used patterns similar to before interventions. However, MAL score discrepancies were not significant in TR groups. The results in TR group were comparable with previous reports (15, 16, 24, 25). In Page's study (2001), the Patients received traditional or no treatment and exhibited no improvements.

In the other study by Gina (2006), patients who received constraint-induced therapy CIT showed more improvement than control group (customary care, ranging from no treatment after formal rehabilitation to pharmacologic or physiotherapeutic interventions). In the present study, patients in TR group received active treatment with intensity of training the same as mCIMT group, therefore the patients in TR group showed improvement and sometimes significant in some parameters.

In this study, spasticity in mCIMT group decreased significantly more than TR group. This result was in accordance with the findings suggested that decrease of spasticity resulted in improvement of daily activities (26).

It seems that repetitive movements might result in neuroplasticity and long-term potentiation. Such a plastic change, presumably involves an increase in synaptic efficiency, and permits reduction in the excitability of the neuronal connections without deterioration of function. Probably CIMT is effective in producing these changes because it increases the motivation in using of the extremity and thereby overcomes the "learned nonuse" (15, 26-28). By training the more affected arm and constraining the less affected arm, CI therapy provides opportunities for positively reinforcing the use of the more affected extremity and adverse consequences for its non-use. In addition, the consequent increase in use, which involved sustained and repeated practice of functional arm movements, might induce expansion of the contralateral cortical area that controls movement of the more affected extremity and recruitment of new ipsilateral areas. This use-dependent cortical reorganization could serve as the neural basis of the permanent increase in the use of the more affected arm.

The patients who demonstrated the greater changes were the most motivated ones in CIT group. These patients were able to write and showed great improvements in fine motor control. In fact, motivation might be a key component of improvement in two patients.

The effect sizes between post-test and pre-test in the above-mentioned outcome measures were moderate to large in mCIMT, ranging from 0.3 to 0.76, but in TR group the effect size were small, ranging from 0 to 0.2.

As the finding demonstrated, two therapeutic methods can be beneficial in some respects, but CIT was more beneficial in the improvement of all parameters and refute the notation that stroke patients can only exhibit gains up to 1 year post-stroke.

This study had some limitations. First, small sample size and second lack of confidence about of using of affected limb in out of clinic special in TR group.

## Conclusion

It seems that the mCIMT treatment was the more effective than TR in improving some parameters. Our study provides additional support for the use of mCIMT during a chronic rehabilitation period of post-stroke patients. CIMT may facilitate functional improvement of an affected hand.

## Conflict of Interests

Authors have no conflict of interests.

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