The Bioscan
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
21(3): S.I (3), 648-653, 2026 www.thebioscan.com

Effect of Constraint-Induced Movement Therapy on Functional Recovery of the Upper Limb in Hemiparetic Patients

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DOI:https://doi.org/10.63001/tbs.2026.v21.i03.S.I(3).pp648-653

KEYWORDS
Hemiparesis; Constraint-Induced Movement Therapy; Upper Limb Rehabilitation; Neuroplasticity; Stroke Rehabilitation.

Received on:30-06-2026

Accepted on:25-07-2026

Published on:31-07-2026

Abstract

Background: Impaired upper-limb use is one of the most disabling consequences of hemiparesis, and learned non use of the affected arm often limits functional recovery. Constraint-Induced Movement Therapy (CIMT) restricts the use of the less-affected arm, thereby promoting intensive, task-oriented use of the affected arm.

Objective: To compare the effectiveness of CIMT and conventional physiotherapy in restoring upper-limb function in individuals with post-stroke hemiparesis.

Methods: This prospective, randomized, comparative two-arm study included 30 adults (40–70 years) with post-stroke upper-limb motor impairment. Participants were allocated to Group A (CIMT, n = 15) or Group B (conventional physiotherapy, n = 15). Group A received mitt restraint of the unaffected arm along with repetitive task-based training of the affected arm, whereas Group B underwent range-of-motion, strengthening, coordination, and functional exercises. Both groups received 30–45 minutes of treatment per session, five times weekly for 6 weeks. Motor recovery and functional performance were assessed at baseline and after 6 weeks using the Fugl-Meyer Assessment for Upper Extremity (FMA-UE) and the Action Research Arm Test (ARAT).

Results: Both groups showed improvement; however, gains were significantly greater in the CIMT group. Mean improvements in FMA-UE (+16.3) and ARAT (+16.7) scores were significantly higher with CIMT ($P < 0.05$).
Conclusion: CIMT is more effective than conventional physiotherapy for enhancing upper-limb motor recovery and functional performance, and represents a feasible task-oriented intervention for individuals with post-stroke hemiparesis.

Introduction

One of the most common and disabling complications of a stroke is called hemiparesis, which is a weakness in muscles on one side of the body. It occurs when the nerve pathways from the cerebral cortex to the spine are damaged and can occur after a brain injury, brain tumour or cerebral palsy. The impact on the motor function varies with the size and location of the lesion and the deficit often is such that the patient cannot do everyday tasks unassisted (1).

The upper extremity is especially susceptible. Reaching, grasping and manipulating objects is difficult due to weakness, inter-joint coordination deficits, abnormal muscle tone and loss of selective motor control. Even if rehabilitation is continued, in many survivors the use of the arm level offs or slows considerably prior to full use (2, 3).

One of the reasons for this plateau is the learned non-use.

Patients resort to repeated unsuccessful attempts to move affected arm, and over time the functional recovery of the affected arm slows down, with its representation in the cortex becoming less and less active (4, 5).

The brain's ability to change and strengthen neural pathways with repeated, task-specific practice (experience-dependent neuroplasticity) is a key factor in successful recovery following central nervous system injury. The process of motor gains and reorganization of the cortex depends on the type of repetition: movement that is avoided is not likely to be relearned while meaningful repetitions are likely to lead to reorganization (6,7).

The result of learned non-use led to the development of constraint induced movement therapy (CIMT). CIMT forces the use of the affected limb and encourages task-oriented, intensive practice of the unaffected limb, thus requiring the impaired arm and taking advantage of use-dependent plasticity to enhance motor control and function in the real world (5, 8).

CIMT has been shown to enhance upper-limb function following a stroke in controlled studies, such as the early study by Taub and colleagues (4) and the multi-site EXCITE trial (9). However, the benefit from these treatments is not universal and the extent of benefit when compared with conventional treatment – especially when the recent treatment periods are clinically pragmatic – is not fully defined (10, 11, 12).

This study thus aimed to compare CIMT with conventional physiotherapy based on the upper-limb motor functions and functional performance of individuals with post-stroke hemiparesis, measured using the Fugl-Meyer Assessment for Upper Extremity (FMA-UE) and the Action Research Arm Test (ARAT) (13, 14).

Methods

Study design

This was a prospective, randomized, two-arm comparative interventional study designed to evaluate the effectiveness of CIMT versus conventional physiotherapy for upper-limb motor recovery in individuals with post-stroke hemiparesis.

Setting and duration

The study was conducted in the Department of Neurological Physiotherapy, Pacific College of Physiotherapy, Pacific Medical University, Udaipur, Rajasthan, India, over a period of 6 weeks.

Participants

Thirty participants with post-stroke hemiparesis were enrolled according to the following criteria.

Inclusion criteria

- Adults aged 40–70 years.
- A confirmed diagnosis of hemiparesis following stroke.
- Presence of upper-limb motor impairment.
- Ability to understand and follow simple verbal instructions.

Exclusion criteria

- Severe cognitive impairment.
- Severe upper-limb spasticity or fixed contracture.
- Other neurological disorders affecting upper-limb function.
- Visual impairment that would interfere with participation.

Randomization and group allocation

Eligible participants were randomly allocated in equal numbers to one of two groups. Group A (n = 15) received CIMT and Group B (n = 15) received conventional physiotherapy. Baseline demographic characteristics of the two groups were comparable (Table 1).

Intervention protocol

Constraint-induced movement therapy (Group A)- CIMT was delivered by restraining the unaffected upper limb with a padded mitt during treatment sessions, while participants were encouraged to use the affected limb in repetitive, task-oriented activities. The programme included reaching activities, grasp-and-release training, block-transfer tasks, peg-board activities and functional hand tasks. This approach promoted active use of the affected limb, countered learned non-use and encouraged motor recovery through massed functional practice. CIMT was provided for 30–45 min per session, 5 days per week, for 6 weeks.

Conventional physiotherapy (Group B)- Conventional rehabilitation aimed to improve motor control and functional use of the affected upper limb and comprised active and active-assisted range-of-motion exercises, strengthening exercises, coordination exercises, reaching activities and functional upper-limb training. Each session lasted approximately 30–45 min.

Outcome measures

Motor recovery of the upper limb was evaluated using the Fugl-Meyer Assessment for Upper Extremity (FMA-UE) and functional performance of the upper limb during grasp, grip, pinch and gross-movement activities was evaluated using the Action Research Arm Test (ARAT). All participants were assessed by the same evaluator for both measures at baseline (pre-intervention) and after 6 weeks (post-intervention).

Statistical analysis

The Statistical Package for the Social Sciences was used to analyse the data. The paired t-test was used to compare within-group changes from baseline to 6 weeks, and the independent-samples t-test was used to compare between-group differences at 6 weeks. A p value < 0.05 was deemed significant. Data are presented as mean ± SD.

Ethical considerations

The study was done with a reference to the guidelines of the Declaration of Helsinki and was cleared by the Institutional Ethics Committee of Pacific Medical University, Udaipur (Approval Number: [to be inserted]). Informed consent was sought and written from all participants prior to enrolment, and participants' identity was kept confidential throughout the study.

Results

At baseline, there were no significant differences in age or sex distribution between the two groups (Table 1). 30 participants finished the 6-week intervention; no adverse events were reported.

Table 1. Baseline characteristics of participants

Variable	Group A – CIMT (n = 15)	Group B – Conventional (n = 15)
Age (years), mean ± SD	58.3 ± 6.8	57.9 ± 7.2
Male, n	10	9
Female, n	5	6

Values are mean ± SD or number of participants. CIMT, constraint-induced movement therapy; SD, standard deviation.

Both groups showed improvement in FMA-UE scores from baseline to 6 weeks, but the gain was substantially larger in the CIMT group. Mean FMA-UE increased from 32.4 ± 4.6 to 48.7 ± 5.1 (mean change +16.3) in Group A, compared with an increase from 31.8 ± 4.3 to 40.5 ± 4.8 (mean change +8.7) in Group B (Table 2).

Table 2. Fugl-Meyer Assessment for Upper Extremity (FMA-UE) scores

FMA-UE score	Pre-treatment (mean ± SD)	Post-treatment (mean ± SD)	Mean change (Δ)
Group A – CIMT (n = 15)	32.4 ± 4.6	48.7 ± 5.1	+16.3
Group B – Conventional (n = 15)	31.8 ± 4.3	40.5 ± 4.8	+8.7

Values are mean ± SD. Δ, post-treatment minus pre-treatment mean. FMA-UE, Fugl-Meyer Assessment for Upper Extremity; CIMT, constraint-induced movement therapy; SD, standard deviation.

A similar pattern was observed for functional performance. Mean ARAT increased from 28.6 ± 5.2 to 45.3 ± 4.9 (mean change +16.7) in the CIMT group and from 27.9 ± 5.0 to 36.8 ± 4.6 (mean change +8.9) in the conventional-therapy group (Table 3).

Table 3. Action Research Arm Test (ARAT) scores

ARAT score	Pre-treatment (mean ± SD)	Post-treatment (mean ± SD)	Mean change (Δ)
Group A – CIMT (n = 15)	28.6 ± 5.2	45.3 ± 4.9	+16.7
Group B – Conventional (n = 15)	27.9 ± 5.0	36.8 ± 4.6	+8.9

Values are mean ± SD. Δ, post-treatment minus pre-treatment mean. ARAT, Action Research Arm Test; CIMT, constraint-induced movement therapy; SD, standard deviation.

The pre- to post-treatment improvements for the FMA-UE and ARAT were statistically significant within each group. More importantly, the post-treatment scores and the magnitude of change, on both outcome measures, were significantly larger in the CIMT group when compared to the conventional-therapy group ($P < 0.05$). The results suggest that CIMT is effective in improving upper-limb motor function and functional performance in PSS patients with hemiparesis.

Discussion

The aim of this study was to assess the impact of CIMT on functional recovery of the upper-limb in 30 patients with hemiparesis due to stroke (mean age 58.3 ± 6.8 years). As with the well-known clinical presentation of hemiparesis, the affected upper extremity showed decreased strength, motor control and movement accuracy, with a corresponding decrease in participation in activities of daily living and the risk of independent living (1).

This kind of restrictions often get reinforced by themselves. Patients tend to favour the non-affected arm when it is not being used, further decreasing use of the impaired arm and diminishing the residual skills necessary for a person's daily function; the core of learned non-use (2). FMA-UE scores were low in both groups at baseline indicating significant motor impairment prior to treatment (13).

Both groups showed improvement after the 6-week programme, with the CIMT group showing much greater improvement on the FMA-UE (Table 2). This approach aligns with the principle of CIMT which states that limiting the free movement of the sound limb will cause the task to be necessary without the affected limb, and will eventually make movement more natural and more useful in daily life (4, 5).

The improvements noted are explained by experience-dependent neuroplasticity. Practice that focuses on a specific task can change the way the motor cortex processes movement, turning unused neural pathways on and making them stronger, and thus enhancing control as the pathways become fixed. The reorganization is not random, but is carried out through persistent and intentional effort (6, 7).

Our results are consistent with earlier studies. Both the early studies by Taub and his colleagues and the later EXCITE trial with multi-site participation showed that CIMT improved arm movement in patients with one-sided weakness, and that this improvement was associated with changes in the brain. (4, 9) These findings, combined with results from the FMA-UE, further support evidence that structured therapy that promotes use of the weaker side elicits greater benefits than conventional exercise-based care alone (10, 11). An important goal of CIMT is to translate the gains measured at the clinic into the real world use of the affected arm, which can be captured by a tool like the Motor Activity Log (15).

Some restrictions should be noted. The sample size was small, the intervention period was short (6 weeks), and follow-up was not conducted at the end of the intervention, so it is not known whether the gains are durable. Other individual factors (e.g., location of lesions, time since stroke, and baseline severity) may have an effect on response to CIMT, but were not analysed here (3, 12). These results need to be confirmed by larger, appropriately powered, multi-centre trials with blinded outcome assessment and longer follow-up to determine which patients are most likely to benefit.

Conclusion

Constraint-induced movement therapy provided a task-oriented approach that enhanced both motor recovery and functional performance of the upper limb to a greater degree than conventional physiotherapy, which is directed more towards general exercise-based rehabilitation. CIMT is therefore an effective intervention for improving functional recovery of the upper limb in patients with post-stroke hemiparesis and merits wider consideration in neurological rehabilitation.

Acknowledgments

The authors thank the participants and the staff of the Department of Neurological Physiotherapy, Pacific College of Physiotherapy, Pacific Medical University, Udaipur, for their support. The authors reviewed and verified all content and take full responsibility for the accuracy, validity, originality and integrity of the work.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial or not-for-profit sectors.

Conflict of Interest Statement

The authors declare that they have no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contribution Statement

Conceptualization: Deepak Lohar, Jafar Khan. Investigation: Nishita Shaurya. Methodology: Nishita Shaurya, Deepak Lohar. Formal analysis: Nishita Shaurya, Deepak Lohar. Supervision: Deepak Lohar, Jafar Khan. Writing – original draft: Nishita Shaurya. Writing – review & editing: Nishita Shaurya, Deepak Lohar, Jafar Khan. All authors approved the final version of the manuscript and agree to be accountable for all aspects of the work.

Ethics approval

This study was conducted in accordance with institutional ethical guidelines and the principles of the Declaration of Helsinki. [Institutional Ethics Committee name and approval number to be inserted by the authors prior to submission.]

Informed consent

Written informed consent was obtained from all participants prior to their inclusion in the study.

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