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Influence of Constraint-Induced Movement Therapy (CIMT) on Acute Post-Stroke Rehabilitation: Upper Extremity Function Recovery and Inclusion in Activities

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Abstract

Background. Constraint-induced movement therapy (CIMT) is widely used in post-stroke rehabilitation and has a positive effect on motor and functional recovery of the affected hand. However, there are insufficient data on the effectiveness of the CIMT method in early post-stroke rehabilitation. Identification of the most effective methods in different periods of recovery after stroke would allow the prioritisation of rehabilitation treatment and create opportunities to achieve the best results.

Aim. To evaluate the effectiveness of the CIMT method on motor recovery, functional capacity, and involvement in activities of the affected hand during early post-stroke rehabilitation (four weeks after stroke).

Methods. The study included 18 patients participating in an inpatient post-stroke rehabilitation programme, who were randomly divided into two groups: Group I – the CIMT method was applied in addition to conventional rehabilitation five times per week for 14 days; Group II (control group) – the conventional rehabilitation programme was applied. Assessment instruments included the Wolf Test, Fugl-Meyer Assessment-Upper Extremity (FMA-UE), dynamometry, Nine-Hole Test (9ST), FNT, ADL / IADL tests and Mini-Mental State Examination (MMSE).

Results. During the two-week rehabilitation programme, application of the CIMT method resulted in a statistically significantly higher motor and functional improvement and more active involvement of the affected upper extremity (UE) in daily activities ($p < 0.05$), compared with conventional rehabilitation.

Conclusions. Even during a short two-week period of the early post-stroke rehabilitation, CIMT provides strong evidence of effectiveness in improving upper limb motor, functional recovery, and increasing involvement in activities.

Keywords: Upper extremity function; performance of activities; involvement in activities; movement restriction therapy

1. INTRODUCTION

Neurological injuries, particularly strokes, often cause significant motor function impairments, most notably affecting upper extremity (UE) movements, which can result in patients losing the ability to independently perform daily and work-related activities (Rocha et al., 2021). Loss of UE function not only limits functional capacity and independence but also has a significant impact on psychological wellbeing – patients often experience depression, anxiety, decreased self-esteem, and reduced quality of life (de Azevedo et al., 2022). Therefore, recovery of upper extremity motor function is one of the most important goals in post-stroke rehabilitation, and successful outcomes can significantly improve overall rehabilitation results by enhancing the patient's level of independence and reducing the risk of disability (Qian et al., 2023). One of the modern, evidence-based methods used for recovery of UE motor function is constraint-induced movement therapy (CIMT). This therapy involves immobilising the healthy extremity and actively encouraging the use of the affected UE, thereby improving its functionality. CIMT is based on the brain's ability to change – so-called neuroplasticity – which allows other brain areas to take over the functions of damaged regions through intense, focused motor activity (Kim et al., 2021). Numerous recent studies show that this therapy not only promotes recovery of motor function but also facilitates active use of the affected hand in activities by suppressing impulses to ignore and avoid using the hand during daily tasks (Dina et al., 2023). In recent years, numerous studies have been conducted to evaluate the effectiveness of CIMT in post-stroke rehabilitation, seeking scientifically based answers regarding the period of recovery after stroke during which the CIMT method is most effective and when the greatest effect is possible. Most often, the results of clinical research support the unequivocal effectiveness of CIMT, but also indicate that success depends on many factors, such as the patient's general condition, the timing and intensity of therapy, individual needs and motivation, the post-stroke period, the severity of the consequences of the stroke, etc. (Hansen et al., 2025). Despite positive results, CIMT is still not widely used in clinical practice, especially during early post-stroke rehabilitation (Zhang et al., 2023), therefore, there is a need to further investigate its effectiveness and application across different periods of post-stroke recovery.

According to recent researches the CIMT method is well-established yet evolving method for motor recovery of affected extremity in post-stroke rehabilitation. The novelty or current advancements in this field revolve around improving the clinical application, expanding its scope, and refining its mechanisms to enhance long-term functional outcomes after stroke. CIMT is generally considered superior to traditional rehabilitation for enhancing functional use of the impaired upper extremity and based on the theory of "Learned Non-Use" can lead to significant, lasting improvements in arm function and daily living activities. We hypothesise that posits the persistent impairment in a stroke survivor's affected upper extremity is largely driven by a behavioural habit of abandoning that extremity in favour of the unaffected one, rather than purely by the physical damage to the brain and even a short exposure to use an affected extremity is effective. The aim of this study was to evaluate the effectiveness of the CIMT method on motor recovery, functional capacity, and involvement in activities of the affected hand during early post-stroke rehabilitation (four weeks after stroke).

2. METHODS

Ethical approval and informed consent. The study was conducted in accordance with the principles of the Declaration of Helsinki. The study was approved by the Institutional Review Board (or Ethics Committee) of Department of Rehabilitation, Faculty of Health Care, Vilniaus kolegija Higher Education Institution (2025-02-19 Protocol No. SP K-16). All participants provided written informed consent prior to participation and before participating were informed about the study aims, methodology, objectives, and participation duration. The empirical study was conducted in January–April 2025 at the Abromiškės Rehabilitation Hospital.

Participants and intervention. Patients participating in post-stroke rehabilitation were invited to participate in the study. Twenty-four stroke patients agreed to participate in the study, but two of them did not complete the study and four did not meet the inclusion criteria, therefore data from 18 subjects were used for the final analysis. The following inclusion criteria: (1) ischaemic stroke, (2) 55–88 years old, (3) stroke-affected arm paresis, (4) acute post-stroke rehabilitation, (5) MMSE score >24 points (no cognitive impairment 24–30, mild impairment 18–23 points) (6) voluntary consent to participate in the study and to use CIMT. Exclusion criteria were the following: (1) haemorrhagic stroke, (2) stroke-affected paralysis, (3) hypertonic stroke-affected arm, (4) recurrent stroke, (5) MMSE score <24 points (severe cognitive impairment 0–17 points), (6) pain syndrome, (7) aphasia. Patients were randomly divided in two groups: intervention group (n = 8) and control group (n = 10) (Table 1).

Table 1. **Characteristics of the participants**

Variables	**Intervention group (n = 8)**	**Control group (n = 10)**	***p*-value**
Age (years)	57–88 years, 65.7 ± 5.7	62–85 years, 64.9 ± 4.8	$p > 0.05^{K}$
Gender (M/W)	5 / 3	8 / 2	NA
Affected arm (R/L)	2 / 6	4 / 6	NA
Stroke onset (weeks)	3.64 ± 1.53	3.96 ± 1.07	$p > 0.05^{K}$
MMSE results	26.1 ± 0.84	26 ± 0.75	$p > 0.05^{A}$

Note: Values are represented as the median (interquartile range). ^{A} ANOVA Test. ^{K} Kruskal–Wallis Test. Stroke onset is the number of weeks before the beginning of a treatment session. L, left; M, men; NA, not applicable; R, right; W, women; MMSE – Mini-Mental State Examination (score, mean ± SD).

All patients participated in conventional post-stroke rehabilitation with standard procedures of physiotherapy, occupational therapy, massage, visits with a social worker and a psychologist lasted 3–4 hours daily, five times per week, for 14 days. Intervention group during occupational therapy sessions was applied CIMT (2-weeks, 45 min/day), then control group participated in conventional occupational therapy sessions. Training sessions were administered under the supervision of an occupational therapist, who familiarised the patient with the therapy by setting individual parameters and conditions. During CIMT sessions the non-affected arm was placed in a padded mitt or sling and participants performed different 10–15 repetitive functional tasks using the affected arm (e.g. eating, grooming, or cleaning, dressing, food preparing or tidying) or performing activities on the table (writing, pouring water, manipulating small objects, turning a key, fastening a zipper). At the start of each training session, the clinician examined UE impairment to assess motor function recovery and identify pain or other complications.

Outcome measures and instruments. The main outcome measures used for the evaluation of the affected UE recovery were the following: the Wolf Test (Turtle et al., 2019), Fugl-Meyer Assessment-Upper Extremity (FMA-UE) (Romano et al., 2025), Hand dynamometry, and Nine-Hole Test (9ST) (Marek et al., 2023) to evaluate the motor and functional issues; the Modified Functional Independence Measure (FIM, 6-item self-care), ADL and IADL tests (Bhaskare, 2025; Pashmdarfard et al., 2020) to evaluate the functional independence and assistance needed in ADL; to measure cognitive impairment, the Mini-Mental State Examination (MMSE) was used. The following assessments were extracted at the beginning (pre-outcomes) and at the end (post-outcomes) of the therapy.

Statistics. Statistical analyses were performed using IBM SPSS Statistics version 23.0. Data are presented as mean ± standard deviation, minima and maxima. Frequencies were calculated for categorical variables. The Shapiro–Wilk Normality Test ($p < 0.05$) was used to verify data normality. Due to the small sample size and non-normal data distribution, non-parametric tests were applied: the Wilcoxon Signed-Rank Test for paired data, Kruskal–Wallis Test for comparisons between groups, McNemar's Test for binary variables, and Chi-Squared tests for categorical associations. Normally-distributed data were compared by means of a parametric statistical method, i.e., with one-way ANOVA ($p < 0.05$). A p-value < 0.05 was considered statistically significant.

3. RESULTS

All results were obtained by comparing the effects of CIMT on motor and functional recovery of the affected UE. In particular, the collected data were divided into three main categories: motor and functional abilities, involvement in daily activities, and functional independence. Both conventional and CIMT-based rehabilitation improved movement, motor function, and functional abilities of the affected UE ($p > 0.05$); however, a significantly greater effect of CIMT was observed even during the short two-week intervention period (Table 2). Nevertheless, no statistically significant differences were found in faster, repetitive movements (Nine-Hole Test) or hand grip strength recovery (dynamometry) ($p > 0.05$). Nevertheless, several distinctive characteristics were observed: CIMT provided the strongest evidence for recovery of the affected UE motor function and movement (FMA-UE, hand dynamometry) and for performance and involvement of the affected UE in activities (Wolf Test) compared with the conventional rehabilitation programme ($p < 0.05$).

Table 2. **Affected upper extremity motor function results (*N* = 18)**

Variables	Intervention group (*n* = 8)	Control group (*n* = 10)	*p*-value
Fugl-Meyer Assessment Upper Extremity			
Pre	32.17 ± 16.5	34.64 ± 14.9	>0.05 [K]
Post	44.55 ± 21.8	44.88 ± 11.9	>0.05 [K]
Post–pre difference	12.38 ± 5.3	10.24 ± 2.33	**<0.05*** [K]
Hand dynamometry (R/L, kg)			
Pre	22.11 ± 14.3 / 25.38 ± 16.2	23.94 ± 16.1 / 23.56 ± 10.7	
Post	26.29 ± 13.0 / 29.22 ± 12.6	26.06 ± 11.8 / 26.54 ± 12.0	
Post–pre difference	4.18 ± 1.85 / 3.84 ± 1.1	2.12 ± 1.87 / 2.94 ± 0.6	<0.05*/>0.05 [A]
Wolf Test			
Pre	58.63 ± 2.88	58.8 ± 2.49	>0.05 [K]
Post	74.25 ± 0.71	68.8 ± 1.32	>0.05 [K]
Post–pre difference	15.62 ± 1.25	10 ± 1.78	**<0.05*** [K]
Nine-Hole Test (9ST, time/minutes)			
Pre	2:11 ± 14.84	2:16 ± 13.63	>0.05 [K]
Post	1:50 ± 17.14	1:57 ± 12.45	>0.05 [K]
Post–pre difference	20.75 ± 10.54	18.70 ± 10.69	>0.05 [K]

Notes: Values are represented as the median (interquartile range) or the mean ± SD. [A] ANOVA Test. [K] Kruskal–Wallis Test. * $p < 0.05$; R/L, affected right and left hand, respectively.

Our results indicated that during the two weeks of rehabilitation the functional independence of the participants increased in both groups ($p > 0.05$), however, we cannot state that the CIMT was more effective in improving the level of functional independence in ADL. According to the conventional programme, significantly higher functional changes were reached in FIM, ADL, and IADL scores ($p < 0.05$) (Table 3).

Table 3. **Functional independence testing results ($N = 18$)**

Variables	Intervention group ($n = 8$)	Control group ($n = 10$)	p-value
Modified FIM score (self-care activities)			
Pre	24.41 ± 5.18	21.40 ± 6.60	>0.05 [A]
Post	31.94 ± 4.39	32.24 ± 3.18	>0.05 [A]
Post–pre difference	7.53 ± 2.50	10.84 ± 6.47	**<0.05*** [A]
Activities of Daily Living Scale (ADL)			
Pre	28.53 ± 2.91	28.22 ± 2.00	>0.05 [A]
Post	33.58 ± 2.45	33.94 ± 2.53	>0.05 [A]
Post–pre difference	5.05 ± 1.50	5.72 ± 0.53	**<0.05*** [A]
Instrumental Activities of Daily Living Scale (IADL)			
Pre	7.25 ± 0.97	7.06 ± 0.58	>0.05 [A]
Post	7.83 ± 0.52	7.95 ± 0.53	>0.05 [A]
Post–pre difference	0.58 ± 0.47	0.89 ± 1.02	**<0.05*** [A]

Notes: Values are represented as mean ± SD; [A] ANOVA test. Post–pre difference, the effect of treatment or changes between post-treatment and baseline * $p < 0.05$; SD – standard deviation.

4. DISCUSSION

Constraint-induced movement therapy (CIMT) is one of the most widely used treatments for enhancing UE motor function and participation in daily activities during post-stroke rehabilitation (Hansen et al., 2025; Zhang et al., 2023). However, the effect of CIMT on functional recovery of the affected UE and its involvement in activities during the acute post-stroke rehabilitation remains unclear and requires further clarification (Morone & Pichiorri, 2023). What determines the effectiveness of CIMT-based early rehabilitation? It is quite clear that the complexity of rehabilitation interventions, as well as patients' physical and emotional conditions and motivation, are among the most significant factors (Borschmann & Hayward, 2020). The results of our study indicated that the CIMT produced a positive effect comparable to conventional rehabilitation interventions: the intervention group demonstrated a significantly higher improvement of the affected UE motor function, muscle strength, movement (FMA-UE, HD, and 9ST results), and arm functional abilities (Wolf Test) compared with the control group ($p < 0.05$). However, we cannot state that the CIMT was more effective in improving the level of functional independence in ADL. Our results indicated that during the two weeks of rehabilitation the functional independence of participants increased in both groups ($p > 0.05$), however, the CIMT-based rehabilitation did not demonstrate a higher result compared with the conventional programme, which demonstrated a significantly higher functional change (FIM, ADL, and IADL score) over the two-week programme ($p < 0.05$). Furthermore, we think that the generalisability of our study results may have been influenced by the small sample size or the fact that the study was conducted at a single rehabilitation unit. However, we can confidently state that successful outcomes may by influenced by the type of constraint, the duration of the CIMT intervention, immobilisation, and variability in recovery outcome measures. With regard to the duration of the CIMT interventions, our study found significant effects of the CIMT on UE motor and arm functional recovery during a two-week programme in early rehabilitation. Nonetheless, the application of constraints for 45 min/day were too short – a more positive effect could be achieved if the constraints were applied not only during rehabilitation sessions but also continued and after sessions during the patient's leisure time in the ward. In our study of acute post-stroke rehabilitation patients, we applied the CIMT shortly (45 min/day) due to weak patients' condition (they got tired easily, needed more time to recover, had lower physical capacity) and physical load dosage restrictions. Treatment sessions for CIMT can vary from 30 minutes to six hours per day and from two to seven sessions per week, for two to 12 weeks (Qian et al., 2023). According to Yang et al. (2023), an efficient CIMT protocol consisting of six hours of training per week combined with six hours of constraint per day can lead to significant improvement in stroke-related symptoms during rehabilitation (Yang et al., 2023).

Positive findings regarding the effects of CIMT on the affected UE motor function, dexterity, fine motor skills, precision of movements, and self-reported arm–hand use in daily life activities have been demonstrated by numerous studies (Bhaskare, 2025; Dina et al., 2023; Qian et al., 2023; Zhang et al., 2023). The results of our study revealed a statistically significant improvement and positive effect on UE function and involvement during a short two-week programme, suggesting that early application of the CIMT method in the acute or subacute post-stroke rehabilitation is highly important, as this process leverages the brain's ability to reorganise and improve functioning (Bhaskare, 2025). It promotes neuroplasticity by forcing the use of the affected extremity through restraint of the stronger one, leading to cortical reorganisation, increased synaptic connections, and improved motor function by enhancing the brain's ability to rewire itself, recruiting neurons from the contralesional cortex and improving brain metabolism and glucose utilisation in motor areas. This intense, task-focused training reduces learned non-use and enhances functional recovery by strengthening neural pathways for the affected extremity (Bhaskare, 2025; Wang et al., 2022). Thus, constraint-induced movement therapy provides strong evidence of effectiveness for upper extremity recovery during early post-stroke rehabilitation, and further application of this method during the subacute or active period of post-stroke rehabilitation may increase the likelihood of achieving better recovery outcomes.

Limitations of this study include a small sample size and a short duration of constraint application (min/day), which may affect the generalisability and reliability of the results.

5. CONCLUSIONS AND PERSPECTIVES

The findings of our study support the use of constraint-induced movement therapy during early post-stroke rehabilitation as an effective intervention for functional recovery of the affected extremity. There is strong evidence that CIMT has greater effects on motor function recovery in the early post-stroke rehabilitation, when restitution of neurological functions is still possible, whereas in the later rehabilitation phases CIMT primarily influences arm–hand activities through learning adaptive (i.e. compensatory) strategies to improve upper limb function. The effect of CIMT on increasing functional independence in ADL was not proven in our study, it is not sufficiently studied, due to required longer exposure time, precise activities involving whole body movements, balance and mobility improvement tasks. These results highlight the role of rehabilitation interventions as a first-line strategy for stroke recovery, providing both motor and functional benefits. Future research should involve larger sample sizes and extend the duration of CIMT to six hours per day. These findings further expand current knowledge regarding the effectiveness of CIMT in post-stroke rehabilitation.

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