JPRM
Journal of Preventive and Rehabilitative Medicine
ISSN: 2415-038X (Print)

2023; 5(2): 136-145
PublishedOnline:08/11/2023
(https://journals.unza.zm/index.php/medicine/about)
DOI: https://doi.org/10.21617/jprm20232.5216

ORIGINAL ARTICLE Open Access

# Efficacy of Constraint Induced Movement Therapy and Mirror Therapy in Improving Upper Extremity Function in Late Subacute and Chronic Stroke Patients: A randomized crossover trial

**Olipa Zulu[1] *, Joseph Lupenga [2], Micah Mutuna Simpamba [1], Martha Banda-Chalwe [1]**

[1] Department of Physiotherapy, School of Health Sciences, University of Zambia, Lusaka, Zambia. [2]Department of Epidemiology and Biostatistics, School of Public Health, University of Zambia, Lusaka, Zambia.

*Corresponding author: zuluolipa@yahoo.com

## Abstract

**To cite:** Zulu O, Lupenga J, Simpamba MM, Banda-Chalwe,M., Efficacy of Constraint Induced Movement Therapy and Mirror Therapy in Improving Upper Extremity Function in Late Subacute and Chronic Stroke Patients: A randomized crossover trial. JPRM 2023, 5(2): 136-145. doi: https://doi.org/10.21617/jprm20232.5216

**Background**: To investigate the efficacy of the combination of Constraint Induced Movement Therapy and Mirror Therapy on functional outcome of the upper extremity for patients with late subacute and chronic stroke.
**Materials and Method**: This study was a single-centre, randomized, single subject blind, 2-way crossover. Recruited 12 participants who had chronic stroke treated at the University Teaching Hospital, department of physiotherapy, Lusaka. Patients were randomly assigned in the group (n=6) of combined therapy or to a group (n=6) of conventional therapy. Microsoft Excel was used for randomization and trial group allocation. The data from the same type of treatment in the two sequences were combined and analysed. The primary analysis compared the range of motion and motor function in the two groups at 6 weeks of follow-up.
**Results**: Constraint Induced Movement Therapy with Mirror Therapy produced a significant improvement in range of motion, activities of daily living, and motor function ($p<0.016$). No significant improvement was observed in the quality of life for either treatment group. However, no significant differences were found between the Constraint Induced Movement Therapy and Mirror Therapy and conventional physiotherapy in terms of improving range of motion, motor function, activities of daily living, and quality of life.
**Conclusion**: Overall, the combination of Constraint Induced Movement Therapy and Mirror Therapy showed better improvement over conventional physiotherapy in the management of upper extremity impairment in late subacute and chronic stroke regarding the range of motion, motor function, and activities of daily living in chronic stroke patients.

**Keywords:** *Stroke, Constraint Induced Movement Therapy, Mirror Therapy, Functional Activity, Upper Extremity, Conventional Physiotherapy*



***Received:*** *3 November 2023* ***Accepted:*** *7 November 2023* ***Published:*** *9 November 2023*

## INTRODUCTION

Stroke continues to be the third-leading cause of death and disability combined worldwide [1,2]. After a stroke, upper limb motor impairments like muscle weakness, loss of dexterity, and altered sensation are common [3]. The initial severity of motor impairment or function seems to be the most significant predictor factor for upper limb recovery after stroke [4]. Because of the poor prognosis, managing the upper extremities after a stroke can be challenging [5,6]. Within the first six months, only 20% of stroke patients regain function [7].

Post-stroke rehabilitation is a huge part of the stroke recovery process, and it often begins as early as 24 hours after the stroke [8,9]. The timeframe for stroke recovery is categorized into hyper-acute (0-24hours), acute (1-7days), early (7 days-3 months) and late (3-6months) sub-acute, and chronic (> 6 months) [10]. Literature recommends various rehabilitation strategies for chronic stroke patients, including muscle-strengthening exercises, constraint-induced movement therapy (CIMT), mirror therapy (MT), mental practice with motor imagery, high frequency-transcutaneous electrical nerve stimulation, repetitive transcranial magnetic stimulation, transcranial direct current stimulation, botulinum toxin, and virtual reality [11,12].

Research has focused on improving motor impairment recovery during stroke recovery, with established methods for mild paralysis, but late subacute and chronic stroke rehabilitation of upper limb paresis remains a challenge [13]. As a result, there is a considerable desire for new treatment approaches to restore chronic upper limb paresis in stroke survivors [13]. The optimal therapy quantity or dose for stroke remains unknown due to the lack of better outcomes associated with more intensive therapies compared to conventional therapy [14]. For hemiplegic stroke patients, CIMT and MT have been shown to be effective treatment interventions [11,12,15,16]. Despite CIMT and MT's effectiveness in improving arm movement, there is insufficient evidence to justify their superiority over other rehabilitation therapies [17–19]. Post-stroke rehabilitation is now focusing on integrated therapeutic methods for long-term upper limb impairments, combining two effective methods to maximize therapeutic advantages [20,21].

In earlier clinical trials, CIMT and MT were combined and proved to be more beneficial than monotherapy [22,23]. The combination of CIMT and mirror treatment in late subacute and chronic stroke patients has limited evidence, as these trials primarily focused on subacute stroke rehabilitation and there is limited evidence that these techniques enhance range of motion. A systematic review suggests that combining MT with another rehabilitation therapy for the upper extremity in stroke patients is more effective than using only one therapy [21]. Therefore, this study aimed to assess the effectiveness of combining CIMT and MT on the upper extremity of stroke patients, focusing on their range of motion, motor function, daily activities, and quality of life.

## MATERIALS AND METHODS

### Study design

This was a single-centre, randomized, double-subject blind, 2-way crossover study conducted among patients with chronic stroke at the University Teaching Hospital (UTH) in Lusaka, Zambia. Participants in Group A began with CIMT and MT before switching to CP. Participants in Group B began with CP before moving on to CIMT and MT. The study was approved by the University of Zambia School of Health Sciences Research Ethics Committee Board (protocol ID number 20203101083).

### Study participants

The study focused on stroke patients in the late subacute and chronic stage aged 18 or older with a stroke lasting over 3 months, those with a 10° extension of their affected joints, those receiving care from guardians or caregivers, and those maintaining a sitting position for more than 30 minutes. The study excluded patients with severe aphasia, depression, musculoskeletal problems, or severe shoulder pain that could limit therapy.

The study was conducted at the University Teaching Hospital's Physiotherapy Department, which treats various musculoskeletal and neurological conditions, with stroke being the common, with an average of 208 stroke patients seen annually.

### Interventions

The therapy regimen consisted of two groups (Group A and Group B). For 12 weeks, all participants attended three treatment sessions per week. The intervention was administered at UTH by a qualified physiotherapist who has been in practice for at least two years and works full-time.

The conventional physiotherapy (CP) intervention was performed with no specific requirements. The techniques employed included proper positioning, conducting group training, performing self-range of motion exercises, avoiding the use of overhead pullies that appear to contribute to shoulder tissue injury, and use of external support during exercises for those that need support. For six weeks, CP was conducted for 45 minutes per day, three days per week. The patients of the CIMT combined with the mirror therapy group did not receive the convention therapy, and the mirror therapy was performed during hours when the CIMT was not done. Before performing CIMT and MT, the following items were required: a sling combined with a resting hand splint, a glove, a mirror, a plastic bowl filled with sand, temperature stimuli, and various brushes. During MT, patients performed unilateral movement of the non-affected arm, bilateral movement with or without an object, guiding of the affected arm by the therapist, and guiding of both arms by the therapist in high sitting on a chair. MT was performed for 30 minutes per day, three days per week, for six weeks. For the CIMT approach, patients performed repetitive, structured, practice intensive therapy in the more affected arm, restraint of the less affected arm, and application of a package of different techniques in various positions. CIMT was performed for 6 hours per day, three days per week, for six weeks.

### Outcomes

The co-primary endpoints were the improvement in range of motion and motor function from baseline. The goniometer was used to measure the range of motion, and the Motor Activity Log was used to assess motor function. The secondary outcomes were Activities of Daily Living (ADL) and Quality of Life. The Barthel Index was used to assess ADL, while the SF-36 Questionnaire was used to assess the quality of life. The parameters were measured at baseline, crossover, and the end of the treatment.

### Measurement tools

The Motor Activity Log (MAL) is a 14-item tool measuring real-world arm use, aiming to assess patients' usage of their affected arm outside the hospital setting, with a reliability score of 0.91 and internal validity of 0.81 [24]. The Barthel Index is a 10-item performance-based instrument used to measure improvement in patients' daily activities (ADLs) with a validity and reliability of over 0.77 [25]. The SF-36 Questionnaire assesses post-stroke quality of life, scoring 36 questions from 0 to 100 with validity and reliability exceeding 0.70 [26,27]. Patients completed the questionnaire at baseline and follow-up, with caregivers aiding those with literacy limitations.

### Sample Size

With the use of an online calculator, a study group design of two independent study groups and a continuous primary endpoint, statistical parameters were set as follows; alpha of 0.05, power of 80%, anticipated mean 1 of 38+/-1, anticipated mean 2 of 39.5 and enrolment ratio of 1. The sample size of 14 participants was concluded with the first group having 7 participants and the second group having 7 participants. The calculator site used was https://clincalc.com/stats/samplesize.aspx

### Randomisation

With a 1:1 allocation, a randomization sequence was generated in Microsoft Excel 19. Participants were randomly assigned to treatment groups A or B using simple randomization procedures and computer-generated numbers, with the allocation sequence concealed from research assistants using opaque, sealed envelopes. Participants' names were written on envelopes, opened in a specific sequence, and stroke patients were screened for eligibility, and those meeting the criteria were invited to participate. Patients were informed about the trial's purpose, ethical concerns, procedures, risks, benefits, and withdrawal option. Written informed consent was obtained, and eligible participants were enrolled using a simple random sampling approach. The study used a double-blind technique, with participants unaware of treatment group assignment and physiotherapists recording outcome measurements without disclosing the treatment.

### Statistical Methods

SPSS 26.0 for Windows was used for statistical analysis (IBM, Armonk, NY, USA). The study used an independent t-test for continuous variables meeting normality assumptions, the Mann-Whitney Test for non-normal variables, and the Fisher exact test for categorical data to compare demographic data. The treatment effects of the two interventions were investigated using repeated measure ANOVA, and if the ANOVA assumptions were not met, a Friedman test was used to test the difference. If ANOVA revealed a statistically significant difference between group means, a paired T-test was used as a post hoc test, and if the Friedman test results were statistically significant, a Wilcoxon signed-rank test was used as a post hoc test. The significance level for the post hoc tests was adjusted by dividing it by the number of comparisons (0.05/3 = 0.0167; Bonferroni correction), resulting in a significance level of p=0.017. Changes between the combined CIMT and MT treatment outcome and CP treatment outcome were compared, regardless of the sequences. That is, data from the same type of treatment in the two sequences were combined and analysed.

## RESULTS

Forty-three patients with late subacute and chronic stroke were assessed for eligibility, and 19 were excluded because they did not meet the study inclusion criteria. 14 patients out of 24 were randomly assigned to one of the two treatment groups. However, during the initial phase of the cross-over, two patients—one from each group—withdrew from the trial because one became ill and was hospitalized while the other was transferred to another medical facility. Twelve patients were therefore included in the study's final analysis (figure 1).

**Demographic characteristics**

The study included 12 patients who had suffered from a stroke. Table 1 reveals no statistical differences in age, stroke duration, paralysis side, hypertension, or stroke cause between the two groups ($p > 0.05$). The study found significant sex differences between two groups, with group 2 primarily consisting of female patients ($p = 0.015$).

**Table 1: Demographic characteristics of study participants**

| | Treatment group | | | |
|---|---|---|---|---|
| Characteristics | Group A (n=6) | Group B (n=6) | Total n (%) | P values |
| Age | 51.5±15.3 | 45.5±9.7 | 48.5±12.7 | 0.435[a] |
| Duration of stroke | 18 (5, 54) | 4.5 (3.5, 18) | 9 (3.25, 24) | 0.240[b] |
| Sex | | | | 0.015[c] |
| Male | 5 (85.7%) | 0 (0%) | 5 (42.7%) | |
| Female | 1 (14.3%) | 6(100%) | 7 (58.3%) | |
| Hypertension | | | | 1.00[c] |
| No | 2 (50%) | 2 (50%) | 4 (33.3%) | |
| Yes | 4 (50%) | 4 (50%) | 8 (66.7%) | |
| Side of paralysis | | | | |
| Left | 3 (42.9%) | 4 (57.1%) | 7 (58.3%) | 0.100[c] |
| Right | 3 (60%) | 2 (40%) | 5 (41.7%) | |
| Causes | | | | 0.182[c] |
| Brain Tumor | 1 (100%) | 0 (0.0%) | 1 (8.3%) | |
| CVA | 5 (62.5%) | 3 (37.5%) | 8 (66.7%) | |
| Unknown | 0 (0.0%) | 3 (100%) | 3 (25.0%) | |

[a] Independent t-test, Values are mean ± standard deviation
[b] Mann-Whitney Test, Values are median (Interquartile range)
[c] Fisher's exact Test

**Primary Outcome**

Intervention's effect on the range of motion

The co-primary outcome of the interventions' effect was improvements in the upper extremity range of motion (ROM). A repeated measure ANOVA analysis compared the degree of change in the mean ROM in each group before and after the intervention. The study found statistically significant differences in the mean ROM in shoulder extension, shoulder internal rotation, shoulder external rotation, wrist flexion, wrist extension, ulna deviation, radial deviation, and phalangeal flexion ($p < 0.05$) (Table 2). Additionally, a Friedman test compared the degree of change in the median ROM in each group before and after the intervention revealed significant differences in the median ROM in shoulder abduction, forearm pronation, forearm supination, phalangeal extension, distal interphalangeal flexion, and finger abduction ($p < 0.05$). Furthermore, the test showed no significant difference in median ROM of shoulder flexion, shoulder adduction, elbow flexion, and proximal interphalangeal flexion ($p < 0.05$ (Table 2).

In a post-hoc analysis, the t-test results showed that after combined CIMT and MT treatment, the mean ROM increased significantly for shoulder extension, shoulder external rotation, and radial deviation (p < 0.017) (Table 3). The Wilcoxon signed-rank test results also showed that after CIMT and MT combined treatment, the median range of motion significantly increased for shoulder abduction, forearm pronation, forearm supination, and finger abduction (p < 0.05) (Table 4). CIMT and MT combined treatment, on the other hand, did not significantly improve the ROM of the following movements: shoulder flexion, adduction, internal rotation, wrist flexion, wrist extension, ulna deviation, phalangeal flexion, phalangeal extension, distal phalangeal flexion, thumb flexion, thumb abduction (p>0.017). With regards to CP treatment, there was no significant improvement in ROM in any of the upper limb movements (p>0.017). Furthermore, in comparing the results of the ROM between the CIMT combined mirror therapy group and the CP group, no significant difference was observed in any of the upper limb movements (p>0.017).

**Table 2: Differences in upper limb joint range of motion at baseline and after two treatments**

| | Treatment group | | | | | |
|---|---|---|---|---|---|---|
| **Range of motion** | **Baseline CIMT/MT** | **CIMT and MT** | **Baseline CP** | **CP** | **Test** | **P values** |
| **Shoulder** | | | | | | |
| Flexion | 150 (83.8, 163.8) | 165 (107.5, 178.8) | 145 (77.5, 173.8) | 155 (106.2, 178.8) | 7.476ᵇ | 0.058 |
| Extension | 30±9.0 | 37.1±10.8 | 30±14.3 | 34.2±10.4 | 15.061ᵃ | 0.001 |
| Abduction | 127.5 (92.5, 155.0) | 152.5 (101.3, 170) | 132.5 (78.8, 158.8) | 147.5 (92.50, 167.5) | 14.00ᵇ | 0.003 |
| Adduction | 30.0 (20.0, 35.0) | 35.0 (22.5, 35.0) | 30.0 (16.3, 35.0) | 32.5 (20.0, 35.0) | 7.333ᵇ | 0.062 |
| Internal rotation | 31.3±16.0 | 36.3±13.3 | 31.3±13.7 | 34.6±15.3 | 4.278ᵃ | 0.035 |
| external rotation | 25.0±11.3 | 31.3±11.7 | 28.3±12.7 | 27.9±12.7 | 5.032ᵃ | 0.018 |
| **Elbow** | | | | | | |
| Flexion | 132.5 (130.0, 135.0) | 135.0 (135.0, 135.0) | 135.0 (103.75, 135.0) | 135 (131.25, 135) | 7.000ᵇ | 0.072 |
| Extension | 0 | 0 | | 0 | | |
| **Forearm** | | | | | | |
| Pronation | 37.5 (22.5, 57.5) | 45.0 (22.5, 68.8) | 37.5 (20.0, 60.0) | 37.5 (22.5, 63.8) | 10.714ᵇ | 0.013 |
| Supination | 37.5 (22.5, 57.5) | 45.0 (22.5, 68.8) | 37.5 (20.0, 60.0) | 37.5 (22.5, 63.8) | 10.714ᵇ | 0.013 |
| **Wrist** | | | | | | |
| Flexion | 50.0±18.1 | 55.4±17.6 | 49.6±16.6 | 54.6±17.8 | 24.212ᵃ | 0.001 |
| Extension | 36.7±16.6 | 40.8±18.8 | 37.8±17.4 | 38.8±15.7 | 6.939ᵃ | 0.008 |
| Ulnar deviation | 11.7±7.8 | 14.6±6.2 | 11.7±7.5 | 12.9±7.2 | 9.364ᵃ | 0.009 |
| radial deviation | 9.2±6.3 | 12.1±5.4 | 10.0±6.7 | 10.4±6.2 | 4.794ᵃ | 0.026 |
| **Metacarpal** | | | | | | |
| Phalangeal flexion | 49.6±19.9 | 55.4±18.2 | 49.6±21.8 | 55.8±16.4 | 14.457ᵃ | 0.001 |
| Phalangeal extension | 12.5(6.3, 25.0) | 15.0 (10.0, 30.0) | 10.0 (5.0, 30.0) | 12.5 (10.0, 30.0) | 9.933ᵇ | 0.019 |
| **Proximal interphalangeal** | | | | | | |
| Flexion | 60.0 (50.0, 65.0) | 62.5 (50.0, 65.0) | 62.5 (38.8, 68.8) | 62.5 (50.0, 65.0) | 2.000ᵇ | 0.572 |
| Extension | 0 | 0 | | 0 | | |
| **Distal interphalangeal** | | | | | | |
| Flexion | 52.5 (35.0, 60.0) | 55.0 (36.3, 71.3) | 52.5 (35.0, 60.0) | 52.5 (35.0, 60.0) | 10.714ᵇ | 0.013 |
| Extension | 0 | 0 | | 0 | | |
| **Finger** | | | | | | |
| Abduction | 7.5 (1.3, 15.0) | 12.5 (10.0, 20.0) | 10.0 (5.0, 15.0) | 10.0 (5.0, 18.8) | 15.545ᵇ | 0.001 |
| Adduction | 0 | 0 | | 0 | | |
| **Thumb** | | | | | | |
| Flexion | 47.1±19.7 | 54.6±19.0 | 50.0±23.6 | 53.3±19.1 | 9.910ᵃ | 0.014 |
| Extension | 0 | 0 | | 0 | | |
| Abduction | 35.4±15.1 | 41.3±16.8 | 35.4±17.2 | 38.3±16.8 | 9.208ᵃ | 0.003 |
| Adduction | 0 | 0 | | 0 | | |
| **Motor activity log** | 1.0±1.1 | 1.8±1.3 | 1.3±1.3 | 1.5±1.4 | 8.372ᵃ | 0.001 |
| **Barthel score** | 80 (56.3, 85) | 85 (75, 90) | 75 (45, 85) | 82.5 (63.8, 85) | 13.207ᵇ | 0.004 |
| **Physical health** | 30.1 (20.2, 38.7) | 41.0 (30.1, 68.5) | 30.2 (22.2, 52.0) | 36.5 (25.4, 68.5) | 6.300ᵇ | 0.043 |
| **Mental health** | 45.2±22.5 | 51.2±18.0 | 46.5±18.4 | 49.7±18.3 | 7.09ᵃ | 0.007 |

ᵃ Repeated measure ANOVA
ᵇ Friedman test

**Effect of Interventions on Motor Function**

Motor Function was the co-primary outcome measure used to assess the effectiveness of the interventions. A repeated measure ANOVA analysis revealed there were statistically significant differences in motor activity log scores (p = 0.001) (Table 2). A post hoc analysis showed that the mean MAL score improved significantly after combined CIMT and MT intervention (p = 0.003) (Table 3). However, no significant improvement was observed after CP intervention, nor was there a significant difference in MAL mean scores between the combined CIMT and MT intervention group and the CP intervention group (p>0.017) (Table 3)

**Table 3: Paired t-test analysis of the differences in range of motion, motor function and mental health after the interventions**

| Pairs | Mean difference | Lower 95% CI | Upper 95% CI | t-test | p value |
|---|---|---|---|---|---|
| **Shoulder Extension** | | | | | |
| CIMT & MT – Baseline | 7.1 | 1.9 | 12.2 | 3.027 | 0.012 |
| CIMT & MT – CP | 2.9 | -0.2 | 6.1 | 2.028 | 0.067 |
| CP – Baseline | 4.2 | -1.4 | 9.7 | 1.650 | 0.127 |
| **Shoulder Internal Rotation** | | | | | |
| CIMT & MT – Baseline | 5.0 | -0.6 | 10.6 | 1.970 | 0.074 |
| CIMT & MT – CP | 1.7 | -2.9 | 6.2 | 0.804 | 0.438 |
| CP – Baseline | 3.3 | -1.4 | 8.1 | 1.542 | 0.151 |
| **Shoulder External Rotation** | 6.3 | 1.7 | 10.8 | 3.045 | 0.011 |
| CIMT & MT – Baseline | 3.3 | -1.0 | 7.7 | 1.685 | 0.120 |
| CIMT & MT – CP | -0.4 | -1.3 | -5.0 | -1.000 | 0.339 |
| CP – Baseline | | | | | |
| **wrist flexion** | | | | | |
| CIMT & MT – Baseline | 5.4 | 0.4 | 10.3 | 2.399 | 0.035 |
| CIMT & MT – CP | 0.8 | -3.8 | 5.5 | 0.394 | 0.701 |
| CP – Baseline | 5.0 | -0.4 | 10.4 | 2.031 | 0.067 |
| **wrist extension** | | | | | |
| CIMT & MT – Baseline | 4.2 | 0.1 | 8.2 | 2.278 | 0.044 |
| CIMT & MT – CP | 2.1 | -1.9 | 6.0 | 1.164 | 0.269 |
| CP – Baseline | 1.0 | -2.0 | 4.0 | 0.739 | 0.476 |
| **ulna deviation** | | | | | |
| CIMT & MT – Baseline | 2.9 | 0.1 | 5.8 | 2.244 | 0.046 |
| CIMT & MT – CP | 1.7 | -1.2 | 4.5 | 1.301 | 0.22 |
| CP – Baseline | 1.5 | -1.5 | 4.1 | 1.000 | 0.339 |
| **radial deviation** | | | | | |
| CIMT & MT – Baseline | 2.9 | 0.8 | 5.0 | 3.023 | 0.012 |
| CIMT & MT – CP | 1.7 | -0.4 | 3.7 | 1.773 | 0.104 |
| CP – Baseline | 0.4 | -1.7 | 2.5 | 0.432 | 0.674 |
| **Phalangeal flexion** | | | | | |
| CIMT & MT – Baseline | 5.8 | -1.4 | 13.1 | 1.765 | 0.105 |
| CIMT & MT – CP | -0.4 | -5.0 | 4.2 | -0.2 | 0.845 |
| CP – Baseline | 6.3 | -1.1 | 13.6 | 1.882 | 0.087 |
| **Thumb flexion** | | | | | |
| CIMT & MT – Baseline | 7.5 | 0.9 | 14.1 | 2.514 | 0.029 |
| CIMT & MT – CP | 1.3 | -1.5 | 4.0 | 1.000 | 0.339 |
| CP – Baseline | 3.3 | -4.0 | 10.7 | 1.000 | 0.339 |
| **Thumb Abduction** | | | | | |
| CIMT & MT – Baseline | 5.8 | 1.2 | 10.5 | 2.755 | 0.019 |
| CIMT & MT – CP | 2.9 | -1.7 | 7.5 | 1.400 | 0.189 |
| CP – Baseline | 2.9 | -0.8 | 6.7 | 1.735 | 0.111 |
| **Motor activity log** | | | | | |
| CIMT & MT – Baseline | 0.8 | 0.3 | 1.2 | 3.792 | 0.003 |
| CIMT & MT – CP | 0.4 | -0.1 | 0.8 | 1.508 | 0.16 |
| CP – Baseline | 0.1 | -0.0 | 0.3 | 1.631 | 0.131 |
| **Mental Health** | | | | | |
| CIMT & MT – Baseline | 6.1 | -0.2 | 12.3 | 2.138 | 0.056 |
| CIMT & MT – CP | 1.5 | -2.6 | 5.7 | 0.815 | 0.432 |
| CP – Baseline | 3.2 | -0.3 | 14.3 | 1.278 | 0.227 |

**Secondary Outcome**

The secondary outcomes examined changes in ADL performance and improvements in quality of life, which was divided into physical and mental health. A Friedman test revealed a significant difference in the median Barthel index scores (p=0.004) (**Error! Reference source not found.**). A Wilcoxon signed-rank test revealed that after CIMT and MT combined treatment, the median Barthel index score increased significantly (p=0.007). The combined CIMT and MT intervention group and the CP intervention group did not significantly vary in median Barthel index scores, and no significant improvement was seen post the CP intervention (p>0.017) (**Error! Reference source not found.**).

Furthermore, the Friedman test and repeated measure ANOVA revealed a significant difference in the scores of physical health and mental health ($p < 0.05$) (**Error! Reference source not found.**). However, a post-hoc analysis revealed no significant variations in physical and mental health scores before and after treatment in each group, as well as between intervention groups (**Error! Reference source not found.**).

**Table 4: Wilcoxon signed-rank test analysis of differences in range of motion, Barthel score, and physical health of the upper limb after interventions**

| | N | Positive Ranks | Negative Ranks | Ties | z score | p value |
|---|---|---|---|---|---|---|
| **shoulder flexion** | | | | | | |
| CIMT &MT – Baseline | 12 | 7 | 1 | 4 | -2.322 | 0.020 |
| CIMT & MT – CP | 12 | 3 | 1 | 8 | -0.921 | 0.357 |
| CP – Baseline | 12 | 4 | 0 | 8 | -1.826 | 0.068 |
| **shoulder abduction** | | | | | | |
| CIMT &MT – Baseline | 12 | 9 | 0 | 3 | -2.673 | 0.008 |
| CP - CIMT & MT | 12 | 5 | 2 | 5 | -1.45 | 0.147 |
| CP – Baseline | 12 | 0 | 6 | 6 | -2.214 | 0.027 |
| **shoulder adduction** | | | | | | |
| CIMT &MT – Baseline | 12 | 4 | 0 | 8 | -1.841 | 0.066 |
| CIMT & MT – CP | 12 | 2 | 0 | 10 | -1.342 | 0.180 |
| CP – Baseline | 12 | 2 | 0 | 10 | -1.342 | 0.180 |
| **Pronation** | | | | | | |
| CIMT &MT – Baseline | 12 | 8 | 0 | 4 | -2.546 | 0.011 |
| CIMT & MT – CP | 12 | 4 | 1 | 7 | -1.511 | 0.131 |
| CP – Baseline | 12 | 4 | 0 | 8 | -1.841 | 0.066 |
| **Supination** | | | | | | |
| CIMT &MT – Baseline | 12 | 7 | 0 | 5 | -2.388 | 0.017 |
| CP - CIMT & MT | 12 | 4 | 1 | 7 | -1.511 | 0.131 |
| CP – Baseline | 12 | 2 | 1 | 9 | -0.535 | 0.593 |
| **phalangeal extension** | | | | | | |
| CIMT &MT – Baseline | 12 | 6 | 0 | 6 | -2.333 | 0.020 |
| CIMT & MT – CP | 12 | 3 | 0 | 9 | -1.732 | 0.083 |
| CP – Baseline | 12 | 2 | 0 | 10 | -1.342 | 0.180 |
| **distal phalangeal flexion** | | | | | | |
| CIMT &MT – Baseline | 12 | 6 | 0 | 6 | -2.207 | 0.027 |
| CIMT & MT – CP | 12 | 3 | 0 | 9 | -1.604 | 0.109 |
| CP – Baseline | 12 | 1 | 0 | 11 | -1.000 | 0.317 |
| **Finger abduction** | | | | | | |
| CIMT &MT – Baseline | 12 | 9 | 0 | 3 | -2.807 | 0.005 |
| CIMT & MT – CP | 12 | 5 | 1 | 6 | -1.667 | 0.096 |
| CP – Baseline | 12 | 2 | 0 | 10 | -0.005 | 0.034 |
| **Barthel index score** | | | | | | |
| CIMT &MT – Baseline | 12 | 9 | 0 | 3 | -2.687 | 0.007 |
| CIMT & MT – CP | 12 | 4 | 3 | 5 | -1.194 | 0.233 |
| CP – Baseline | 12 | 7 | 1 | 4 | -1.973 | 0.049 |
| **physical health score** | | | | | | |
| CIMT &MT – Baseline | 12 | 4 | 0 | 8 | -1.826 | 0.068 |
| CIMT & MT – CP | 12 | 2 | 1 | 9 | 0 | 1.00 |
| CP – Baseline | 12 | 3 | 1 | 8 | -1.095 | 0.273 |

## DISCUSSION

The present study aimed to test the hypothesis that combined CIMT and MT interventions is effective in the management of the upper limb in late subacute and chronic stroke. The most significant observation of this study is that combined CIMT and MT interventions produced a significant improvement in range of motion, activities of daily living, and motor function.

The study reveals that combined CIMT and MT interventions significantly improve upper extremity ROM after late subacute and chronic stroke. The intervention improved shoulder abduction, extension, external rotation, forearm pronation, supination, radial deviation, and finger abduction. Although there was no significant difference in ROM between the CIMT combined mirror therapy and CP groups, the results suggest that combined CIMT and MT intervention may be more effective than CP alone. This finding demonstrates the benefit of integrating integrated treatment approaches into everyday practice as a mix of evidence-based therapies is regarded as standard care across the post-acute care continuum to achieve the motor goals of stroke patients [28].

The study indicates that combining CIMT and MT can potentially enhance the motor function of stroke patients. The study found that combined CIMT and MT significantly improved upper extremity motor function in late subacute and chronic stroke patients after six weeks of treatment, whereas CP treatment did not. This is consistent with the findings of Anwar et al. which found that the CIMT combined MT group achieved more significant improvement in motor functions of the upper extremity than the CIMT only [22]. The observed findings are also supported by other studies show that CIMT and MT improve upper motor function in stroke patients, but are not superior to conservative treatment [17,22,29].

The study revealed that combining CIMT with MT significantly improved daily living activity performance, a finding not observed after CP treatment. This study's findings may be explained by the fact that both MT and CIMT therapies have been shown to improve daily activities [20,29–32]. Therefore, the intervention's effect on daily activity performance may have been enhanced by combining CIMT and MT. Despite the significant improvement in ADL performance by CIMT and MT, no significant differences were observed between the CIMT and MT group and the CP group. In agreement with the results of this study, Adelusola, Osundiya, and Olawale concluded that neither MT nor CIMT significantly improved ADL performance when compared to conventional therapy alone [33].

Post-treatment, neither treatment group showed a significant improvement in quality of life. A meta-analysis, for example, found mCIMT to be a more effective intervention when addressing hemiparesis and quality of life [34], which contradicts the findings of this study. There may be several reasons for these findings. As there is a strong link between arm use and quality of life, maximising quality of life gains during motor rehabilitation in chronic post-stroke patients requires improving arm use during daily activities [35]. The 6-week treatment period may have been too short to witness a significant change in arm use and later quality of life. Stock et al's [36] study also revealed that the early CIMT intervention group recovered faster than the delayed intervention group, suggesting that CIMT may have been less effective in improving quality of life for late subacute and chronic stroke patients.

The study had some limitations. The study's effectiveness was measured after six weeks of treatment, which may not have been enough to observe significant recovery. The small number of patients limit the generalizability of the findings. Larger trials are needed to assess the efficacy of the combination of CIMT and MT on the upper extremity in patients with late subacute and chronic stroke.

## CONCLUSION

The combination of CIMT and MT in managing the upper limb in chronic stroke patients significantly improved ROM, ADLs, and motor function. However, there was no statistically significant difference between the two treatments, making it difficult to determine the superior treatment approach. Further research is needed to determine the best treatment.

## DECLARATION

**Author contribution** OZ was involved in the conceptualization, design of the study, data collection, analysis and writing of the manuscript. JL was involved in the data analysis, writing and reviewing of the manuscript. MMS was involved in the design of the study, writing and reviewed the manuscript. LAN was involved in the design of the study, writing and reviewed the manuscript. MBC was involved in the conceptualization, design of the study,

writing and reviewing of the manuscript. All authors approved the final manuscripts.

**Competing interests** There were no competing interests from all authors in this study.

**Funding** None

## REFERENCES

1. GBD 2019 Stroke Collaborators. Global, regional, and national burden of stroke and its risk factors, 1990-2019: a systematic analysis for the Global Burden of Disease Study 2019. Lancet Neurol [Internet]. 2021 Oct;20(10):795–820. Available from: http://dx.doi.org/10.1016/S1474-4422(21)00252-0
2. Krishnamurthi RV, Ikeda T, Feigin VL. Global, regional and country-specific burden of ischaemic stroke, intracerebral haemorrhage and subarachnoid haemorrhage: A systematic analysis of the Global Burden of disease study 2017. Neuroepidemiology [Internet]. 2020 Feb 20;54(2):171–9. Available from: https://europepmc.org/article/med/32079017
3. Lang CE, Bland MD, Bailey RR, Schaefer SY, Birkenmeier RL. Assessment of upper extremity impairment, function, and activity after stroke: foundations for clinical decision making. J Hand Ther [Internet]. 2013 Apr-Jun;26(2):104-14;quiz 115. Available from: http://dx.doi.org/10.1016/j.jht.2012.06.005
4. Coupar F, Pollock A, Rowe P, Weir C, Langhorne P. Predictors of upper limb recovery after stroke: a systematic review and meta-analysis. Clin Rehabil [Internet]. 2012 Apr;26(4):291–313. Available from: http://dx.doi.org/10.1177/0269215511420305
5. Nakashima A, Moriuchi T, Mitsunaga W, Yonezawa T, Kataoka H, Nakashima R, et al. Prediction of prognosis of upper-extremity function following stroke-related paralysis using brain imaging. J Phys Therapy Sci [Internet]. 2017 Aug;29(8):1438–43. Available from: http://dx.doi.org/10.1589/jpts.29.1438
6. Ward NS. Stroke: mechanisms, stratification and implementation. J Neurol Neurosurg Psychiatry [Internet]. 2013 Mar;84(3):237–8. Available from: http://dx.doi.org/10.1136/jnnp-2013-304886
7. Kwakkel G, van Wegen EEH, Burridge JH, Winstein CJ, van Dokkum LEH, Alt Murphy M, et al. Standardized measurement of quality of upper limb movement after stroke: Consensus-based core recommendations from the second Stroke Recovery and Rehabilitation Roundtable. Neurorehabil Neural Repair [Internet]. 2019 Nov;33(11):951–8. Available from: https://journals.sagepub.com/doi/abs/10.1177/1545968319886477
8. Perre A. Obesity's Role in Lifestyle-Driven Cancers & What Can Be Done About It. Oncology Times [Internet]. 2018 Dec 5 [cited 2022 Dec 9];40(23):42. Available from: https://journals.lww.com/oncology-times/Fulltext/2018/12050/Obesity_s_Role_in_Lifestyle_Driven_Cancers___What.16.aspx
9. Sundseth A, Thommessen B, Rønning OM. Outcome after mobilization within 24 hours of acute stroke: a randomized controlled trial. Stroke [Internet]. 2012 Sep;43(9):2389–94. Available from: http://dx.doi.org/10.1161/STROKEAHA.111.646687
10. Bernhardt J, Hayward KS, Kwakkel G, Ward NS, Wolf SL, Borschmann K, et al. Agreed definitions and a shared vision for new standards in stroke recovery research: The Stroke Recovery and Rehabilitation Roundtable taskforce. Int J Stroke [Internet]. 2017 Jul;12(5):444–50. Available from: http://dx.doi.org/10.1177/1747493017711816
11. Hatem SM, Saussez G, Della Faille M, Prist V, Zhang X, Dispa D, et al. Rehabilitation of Motor Function after Stroke: A Multiple Systematic Review Focused on Techniques to Stimulate Upper Extremity Recovery. Front Hum Neurosci [Internet]. 2016 Sep 13;10:442. Available from: http://dx.doi.org/10.3389/fnhum.2016.00442
12. Pollock A, Farmer SE, Brady MC, Langhorne P, Mead GE, Mehrholz J, et al. Interventions for improving upper limb function after stroke. Cochrane Database Syst Rev [Internet]. 2014 Nov 12;2014(11):CD010820. Available from: http://dx.doi.org/10.1002/14651858.CD010820.pub2
13. Angerhöfer C, Colucci A, Vermehren M, Hömberg V, Soekadar SR. Post-stroke Rehabilitation of Severe Upper Limb Paresis in Germany - Toward Long-Term Treatment With Brain-Computer Interfaces. Front Neurol [Internet]. 2021 Nov 18;12:772199. Available from: http://dx.doi.org/10.3389/fneur.2021.772199
14. Belagaje SR. Stroke Rehabilitation. Continuum [Internet]. 2017 Feb;23(1, Cerebrovascular Disease):238–53. Available from: http://dx.doi.org/10.1212/CON.0000000000000423
15. Colomer C, NOé E, Llorens R. Mirror therapy in chronic stroke survivors with severely impaired upper limb function: a randomized controlled trial. Eur J Phys Rehabil Med [Internet]. 2016 Jun;52(3):271–8. Available from: https://www.ncbi.nlm.nih.gov/pubmed/26923644
16. Gandhi DB, Sterba A, Khatter H, Pandian JD. Mirror Therapy in Stroke Rehabilitation: Current Perspectives. Ther Clin Risk Manag [Internet]. 2020 Feb 7;16:75–85. Available from: http://dx.doi.org/10.2147/TCRM.S206883
17. Etoom M, Hawamdeh M, Hawamdeh Z, Alwardat M, Giordani L, Bacciu S, et al. Constraint-induced movement therapy as a rehabilitation intervention for upper extremity in stroke patients: systematic review and meta-analysis. Int J Rehabil Res [Internet]. 2016 Sep;39(3):197–210. Available from: http://dx.doi.org/10.1097/MRR.0000000000000169
18. Abdullahi A, Van Criekinge T, Umar NA, Zakari UU, Truijen S, Saeys W. Effect of constraint-induced movement therapy on persons-reported outcomes of health status after stroke: a systematic review and meta-analysis. Int J Rehabil Res [Internet]. 2021 Mar 1;44(1):15–23. Available from: http://dx.doi.org/10.1097/MRR.0000000000000446
19. Hartman K, Altschuler EL. Mirror Therapy for Hemiparesis Following Stroke: A Review. Current Physical Medicine and Rehabilitation Reports [Internet]. 2016 Dec 1;4(4):237–48. Available from: https://doi.org/10.1007/s40141-016-0131-8
20. Pérez-Cruzado D, Merchán-Baeza JA, González-Sánchez M, Cuesta-Vargas AI. Systematic review of mirror therapy compared with conventional rehabilitation in upper extremity function in stroke survivors. Aust Occup Ther J [Internet]. 2017 Apr;64(2):91–112. Available from:

https://onlinelibrary.wiley.com/doi/abs/10.1111/1440-1630.12342

21. Luo Z, Zhou Y, He H, Lin S, Zhu R, Liu Z, et al. Synergistic Effect of Combined Mirror Therapy on Upper Extremity in Patients With Stroke: A Systematic Review and Meta-Analysis. Front Neurol [Internet]. 2020 Apr 2;11:155. Available from: http://dx.doi.org/10.3389/fneur.2020.00155
22. Anwar N, Wang S, Yu L, Tan B. Effectiveness of Constraint-Induced Movement Therapy combined with Mirror Therapy on Upper Motor Functions in Stroke Patients. J Nov Physiother [Internet]. 2021 Mar 30 [cited 2022 Dec 9];11(3):1–6. Available from: https://www.omicsonline.org/peer-reviewed/effectiveness-of-constraintinduced-movement-therapy-combined-with-mirror-therapy-on-upper-motor-functions-in-stroke-patients-115466.html
23. Yoon JA, Koo BI, Shin MJ, Shin YB, Ko HY, Shin YI. Effect of constraint-induced movement therapy and mirror therapy for patients with subacute stroke. Ann Rehabil Med [Internet]. 2014 Aug;38(4):458–66. Available from: http://dx.doi.org/10.5535/arm.2014.38.4.458
24. Uswatte G, Taub E, Morris D, Vignolo M, McCulloch K. Reliability and validity of the upper-extremity Motor Activity Log-14 for measuring real-world arm use. Stroke [Internet]. 2005 Nov;36(11):2493–6. Available from: http://dx.doi.org/10.1161/01.STR.0000185928.90848.2e
25. Ohura T, Hase K, Nakajima Y, Nakayama T. Validity and reliability of a performance evaluation tool based on the modified Barthel Index for stroke patients. BMC Med Res Methodol [Internet]. 2017 Aug 25;17(1):131. Available from: http://dx.doi.org/10.1186/s12874-017-0409-2
26. Bunevicius A. Reliability and validity of the SF-36 Health Survey Questionnaire in patients with brain tumors: a cross-sectional study. Health Qual Life Outcomes [Internet]. 2017 May 4;15(1):92. Available from: http://dx.doi.org/10.1186/s12955-017-0665-1
27. Brazier JE, Harper R, Jones NM, O'Cathain A, Thomas KJ, Usherwood T, et al. Validating the SF-36 health survey questionnaire: new outcome measure for primary care. BMJ [Internet]. 1992 Jul 18;305(6846):160–4. Available from: http://dx.doi.org/10.1136/bmj.305.6846.160
28. Lin SH, Dionne TP. Interventions to Improve Movement and Functional Outcomes in Adult Stroke Rehabilitation: Review and Evidence Summary. J Particip Med [Internet]. 2018 Jan 18;10(1):e3. Available from: http://dx.doi.org/10.2196/jopm.8929
29. Liu XH, Huai J, Gao J, Zhang Y, Yue SW. Constraint-induced movement therapy in treatment of acute and sub-acute stroke: a meta-analysis of 16 randomized controlled trials. Neural Regeneration Res [Internet]. 2017 Sep;12(9):1443–50. Available from: http://dx.doi.org/10.4103/1673-5374.215255
30. Kim K, Lee S, Kim D, Lee K, Kim Y. Effects of mirror therapy combined with motor tasks on upper extremity function and activities daily living of stroke patients. J Phys Therapy Sci [Internet]. 2016 Jan;28(2):483–7. Available from: http://dx.doi.org/10.1589/jpts.28.483
31. Uswatte G, Taub E, Bowman MH, Delgado A, Bryson C, Morris DM, et al. Rehabilitation of stroke patients with plegic hands: Randomized controlled trial of expanded Constraint-Induced Movement therapy. Restor Neurol Neurosci [Internet]. 2018;36(2):225–44. Available from: http://dx.doi.org/10.3233/RNN-170792
32. Yang Y, Zhao Q, Zhang Y, Wu Q, Jiang X, Cheng G. Effect of Mirror Therapy on Recovery of Stroke Survivors: A Systematic Review and Network Meta-analysis. Neuroscience [Internet]. 2018 Oct 15;390:318–36. Available from: http://dx.doi.org/10.1016/j.neuroscience.2018.06.044
33. Adelusola PB, Osundiya OC, Olawale OA. Efficacy of Mirror Therapy and Constraint Induced Movement Therapy on Upper. Journal of Stroke & [Internet]. 2022; Available from: https://www.ruh.nhs.uk/library/up_to_date/documents/Stroke_2022_03.pdf
34. Scordalakes H. A Meta-Analysis Evaluating the Effectiveness of Mirror Therapy vs Modified Constraint-Induced Movement Therapy on Upper Extremity Hemiparesis and Quality of Life in Patients with Subacute Stroke [Internet]. search.proquest.com; 2020. Available from: https://search.proquest.com/openview/afe2e18d4542f8f0fed09b543cbea444/1?pq-origsite=gscholar&cbl=18750&diss=y
35. Kelly KM, Borstad AL, Kline D, Gauthier LV. Improved quality of life following constraint-induced movement therapy is associated with gains in arm use, but not motor improvement. Top Stroke Rehabil [Internet]. 2018 Oct;25(7):467–74. Available from: http://dx.doi.org/10.1080/10749357.2018.1481605
36. Stock R, Thrane G, Anke A, Gjone R, Askim T. Early versus late-applied constraint-induced movement therapy: A multisite, randomized controlled trial with a 12-month follow-up. Physiother Res Int [Internet]. 2018 Jan;23(1):e1689. Available from: https://onlinelibrary.wiley.com/doi/abs/10.1002/pri.1689