INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

CONSTRAINT-INDUCED MOVEMENT THERAPY VS. MIRROR THERAPY ON HAND FUNCTION AND SPASTICITY IN PATIENTS WITH HEMIPARESIS

Original Research (ID: 1678)

Mahnoor Aleem[1], Sarfraz Ahmed[2], Abdul Manan[3], Samia Khaliq[4], Sania Zahra[5], Iqra Waseem*[6]
[1]PT, DPT, MS(Neuro), Student, University Institute of Physical Therapy, University of Lahore, Lahore, Pakistan
[2]Associate Professor, Department of Physiotherapy, DIPMR, Dow University of Health Sciences;
[3]Clinical Physiotherapist, Doctor of Physical Therapy, The University of Faisalabad
[4]Lecturer, Alshifa Institute of Health Sciences, Narowal, Pakistan; Consultant Physiotherapist, Iqbal Medical Complex
[5]PT, DPT, MS Neuromuscular Physical Therapy, Head of Department, ACE Institute of Medical & Emerging Sciences, Lahore, Pakistan;
[6]PT, DPT, MS (MSK), Assistant Professor, University Institute of Physical Therapy, University of Lahore, Lahore, Pakistan
Corresponding Author: Iqra Waseem, iqra.waseem91@gmail.com, PT, DPT, MS (MSK), Assistant Professor, University Institute of Physical Therapy, University of Lahore, Lahore, Pakistan

Acknowledgement: The authors gratefully acknowledge all participants and physiotherapy staff who supported the completion of this study.

Conflict of Interest: None | Grant Support & Financial Support: None

ABSTRACT

Background: Hemiparesis commonly affects upper limb control and limits hand use during daily activities. Reduced voluntary movement, impaired dexterity, and spasticity may delay functional independence and reduce participation in rehabilitation. Constraint-Induced Movement Therapy and Mirror Therapy are widely used neurorehabilitation approaches that aim to promote motor recovery through different mechanisms. However, direct evidence comparing their effects on hand function and spasticity over a structured intervention period remains limited.
Objective: To compare the effects of Constraint-Induced Movement Therapy and Mirror Therapy on hand function and spasticity in patients with hemiparesis.
Methods: A single-blinded randomized controlled trial was conducted on 68 patients with hemiparesis. Participants were randomly allocated into two equal groups, with 34 patients in the Constraint-Induced Movement Therapy group and 34 patients in the Mirror Therapy group. Both groups received their assigned intervention for 8 weeks along with routine physiotherapy care. Hand function was assessed using the Fugl-Meyer Assessment-Upper Extremity, while spasticity was evaluated using the Modified Ashworth Scale. Assessments were recorded at baseline, 4th week, and 8th week. Data were analyzed using descriptive statistics, repeated-measures ANOVA, and independent-samples t-test, with statistical significance set at $p < 0.05$.
Results: The mean age was 53.65 ± 8.05 years in the Constraint-Induced Movement Therapy group and 53.41 ± 7.14 years in the Mirror Therapy group. Modified Ashworth Scale scores decreased from 2.06 ± 0.47 to 0.98 ± 0.65 in the Constraint-Induced Movement Therapy group and from 2.02 ± 0.65 to 1.00 ± 0.42 in the Mirror Therapy group. Fugl-Meyer Assessment-Upper Extremity scores increased from 31.17 ± 4.60 to 40.45 ± 5.69 in the Constraint-Induced Movement Therapy group and from 30.49 ± 5.70 to 41.68 ± 5.78 in the Mirror Therapy group. Within-group improvement was significant for both outcomes over time, with $p < 0.001$. Between-group differences remained statistically non-significant at all assessment points.
Conclusion: Both interventions improved hand function and reduced spasticity in patients with hemiparesis. Mirror Therapy showed slightly greater motor improvement within the 8-week period, suggesting its practical value as an accessible and patient-friendly rehabilitation option.
Keywords: Activities of Daily Living; Constraint Induced Movement Therapy; Hemiparesis; Mirror Movement Therapy; Muscle Spasticity; Stroke; Upper Extremity.

INTRODUCTION

Hemiparesis is a common and disabling neurological condition in which weakness or impaired voluntary movement affects one side of the body. It is most frequently observed after stroke, although it may also occur following other forms of brain injury. Depending on the site and nature of the lesion, weakness may appear on the same side or the opposite side of the body, and the degree of impairment may range from mild loss of coordination to severe functional limitation (1,2). For many patients, hemiparesis is not limited to muscle weakness alone; it may also be accompanied by altered sensation, reduced balance, difficulty in standing or walking, impaired postural control, and reduced confidence in using the affected limb during daily activities (3). These limitations can significantly disturb independence in essential tasks such as eating, dressing, grooming, writing, holding objects, and safe mobility, making upper limb recovery an important priority in neurorehabilitation (4). Upper limb involvement after hemiparesis is particularly challenging because hand function is closely linked with personal independence, social participation, and quality of life. Even when walking ability improves, persistent weakness, poor dexterity, abnormal tone, and spasticity of the affected upper limb may continue to restrict functional recovery. Spasticity can interfere with selective movement, hand opening, grasp release, hygiene, positioning, and task performance, while associated complications such as shoulder pain may further reduce participation in therapy. Hemiplegic shoulder pain has been reported as a frequent problem in rehabilitation settings, with an estimated prevalence of 37%, emphasizing the need for early and targeted therapeutic strategies that address both movement recovery and secondary complications (5). Therefore, effective rehabilitation should not only aim to improve strength and range of motion but should also promote meaningful use of the affected hand in real-life activities. Contemporary stroke rehabilitation increasingly focuses on approaches that encourage neuroplasticity, repetitive task practice, sensory-motor relearning, and active participation of the affected limb. Among these approaches, Constraint-Induced Movement Therapy and Mirror Therapy have gained considerable attention as practical and evidence-supported interventions for improving upper limb recovery in patients with hemiparesis (6). Both therapies are based on the principle that the brain can reorganize itself when appropriate sensory and motor input is repeatedly provided. However, they differ in their mechanisms, mode of application, and the level of physical demand placed on the patient. This difference makes their comparison clinically important, especially for patients who present with varying levels of hand function, spasticity, motivation, and tolerance to intensive rehabilitation. Constraint-Induced Movement Therapy is a structured rehabilitation method designed to increase the functional use of the affected upper limb by limiting the use of the unaffected limb. In this approach, the less affected limb is commonly restrained for a defined period, encouraging the patient to use the paretic limb during repetitive, task-oriented activities (7). The rationale behind this therapy is based on overcoming "learned non-use," a phenomenon in which patients gradually avoid using the affected limb because of weakness, difficulty, or repeated failure during early recovery. Through repeated practice, shaping of functional tasks, and forced use of the affected hand, Constraint-Induced Movement Therapy may enhance cortical reorganization, improve motor control, increase strength, and support better independence in activities of daily living (8). Despite its potential benefits, it requires patient cooperation, adequate baseline movement, and careful clinical supervision to ensure that the intervention is safe, tolerable, and functionally meaningful.

Mirror Therapy, on the other hand, is a visually guided rehabilitation technique that uses the reflection of the unaffected limb to create the illusion that the affected limb is moving normally. During therapy, a mirror is placed in the midline so that movements of the unaffected hand are reflected as if they are being performed by the affected hand. This visual feedback may stimulate motor-related brain areas, support motor imagery, reduce abnormal sensory-motor mismatch, and encourage recovery of movement in the paretic limb (9). Mirror Therapy is relatively simple, low-cost, non-invasive, and easy to apply in both clinical and home-based rehabilitation settings. It may be especially useful for patients who have limited active movement in the affected hand, as the visual illusion can help engage motor planning pathways even when actual movement is reduced. Reported benefits include improvement in motor performance, range of motion, strength, and functional use of the affected upper limb (10). Existing literature supports the therapeutic value of both Constraint-Induced Movement Therapy and Mirror Therapy in post-stroke upper limb rehabilitation. Shamweel and Gupta reported that traditional Constraint-Induced Movement Therapy and telerehabilitation-based Constraint-Induced Movement Therapy produced comparable improvements in upper limb function, suggesting that remotely delivered therapy may also be a feasible option for selected patients (11). Rocha et al. found that Constraint-Induced Movement Therapy helped reduce muscle tone and improve functional use of the paretic upper limb, with positive effects on quality of life among individuals with chronic stroke (12). Similarly, Dave et al. reported that Mirror Therapy combined with conventional physiotherapy produced significant improvement in upper extremity function among patients with hemiplegia when compared with physiotherapy alone (13). These findings indicate that both interventions can contribute to motor recovery, yet they also raise an important clinical question: whether one approach offers greater benefit than the other when hand function and spasticity are considered together.

Although previous studies have examined Constraint-Induced Movement Therapy, Mirror Therapy, telerehabilitation models, and combined sensory-motor rehabilitation strategies, direct comparison between Constraint-Induced Movement Therapy and Mirror Therapy for hand function and spasticity in patients with hemiparesis remains insufficiently explored. Many available studies focus primarily on general upper limb function, while fewer address spasticity as a concurrent outcome. In addition, the optimal selection of therapy for patients with different levels of impairment remains uncertain. This creates a practical gap for physiotherapists and rehabilitation professionals, who must decide which intervention may be more appropriate, feasible, and effective for improving functional hand use while reducing abnormal muscle tone. The present study is therefore designed to compare the effects of Constraint-Induced Movement Therapy and Mirror Therapy on hand function and spasticity in patients with hemiparesis. The research question is whether Constraint-Induced Movement Therapy produces superior improvement in hand function and reduction in spasticity compared with Mirror Therapy, or whether Mirror Therapy provides comparable therapeutic benefits with a simpler and less demanding mode of application. The objective of this study is to determine and compare the effectiveness of Constraint-Induced Movement Therapy and Mirror Therapy in improving hand function and reducing spasticity among patients with hemiparesis, so that rehabilitation planning can be guided by clearer evidence and more patient-centered clinical decision-making.

METHODS

This single-blinded, parallel-group randomized clinical trial was conducted at the Department of Physiotherapy, University of Lahore Teaching Hospital, Lahore, over a period of nine months after approval of the research synopsis. The trial was registered under Trial Registration Number NCT06910904. The study was designed to compare the effects of Constraint-Induced Movement Therapy and Mirror Therapy on upper extremity motor function and spasticity among patients with post-stroke hemiparesis. Ethical approval was obtained from the Research Ethics Committee of the University of Lahore before participant recruitment. All participants were informed about the purpose, procedures, possible benefits, and voluntary nature of the study. Written informed consent was obtained before enrolment, and participants were allowed to withdraw from the study at any stage without penalty. Confidentiality was maintained by anonymizing participant data, and the study was conducted in accordance with the ethical principles of the Declaration of Helsinki. A total of 68 participants were recruited through purposive sampling and then randomly allocated into two equal groups, with 34 participants in each group. The sample size was calculated using G*Power software on the basis of previously reported findings (14). The calculation was performed at a 95% confidence level and 80% statistical power, using expected mean Fugl-Meyer Assessment scores of 49.25 in Group A and 70.13 in Group B, with standard deviations of 25.21 and 25.80, respectively. The minimum required sample size was estimated as 23 participants per group; however, the number was increased to 34 participants per group to compensate for possible dropouts and to strengthen the final analysis. The participant flow throughout recruitment, allocation, follow-up, and analysis was documented according to the CONSORT approach and presented in Figure 1.

Participants were eligible for inclusion if they were between 40 and 65 years of age, of either gender, and had post-stroke hemiparesis for a duration of 14 to 90 days (15,16). Patients were also required to have mild to moderate motor impairment with early-stage recovery characteristics, functional limitation of hand motor activity, and the ability to understand and follow verbal and visual commands during therapeutic sessions (17-19). Patients were excluded if they had a history of any other neurological disorder, unstable fracture, significant orthopedic limitation, physical restriction preventing participation in mirror therapy, previous shoulder instability, or prior orthopedic surgery involving the affected upper limb (18-20). These criteria were applied to ensure patient safety, reduce clinical heterogeneity, and include participants who could actively participate in the assigned rehabilitation program. After baseline screening and informed consent, eligible participants were randomly assigned to either the Constraint-Induced Movement Therapy group, labelled as Group A, or the Mirror Therapy group, labelled as Group B, using the lottery method. Due to the nature of the interventions, blinding of participants and treating physiotherapists was not feasible; however, the outcome assessor remained blinded to group allocation throughout the assessment process. Baseline demographic and clinical data were recorded before the start of treatment. Follow-up assessments were performed at the 1st, 4th, and 8th week of the intervention period to evaluate changes in motor recovery and spasticity over time.

Both groups received routine physiotherapy care throughout the study period. Standard physiotherapy included general upper limb mobility exercises, strengthening exercises, and individualized hand exercises delivered 1–2 times per week according to patient tolerance and clinical need. In addition to routine physiotherapy, Group A received Constraint-Induced Movement Therapy, while Group B received Mirror Therapy for eight weeks. Participants in Group A received Constraint-Induced Movement Therapy consisting of two-hour daily supervised therapy sessions, five days per week, along with restraint of the unaffected upper limb for six hours per day to encourage active use of the paretic arm. The intervention focused on repetitive, task-oriented functional activities such as grasping, object manipulation, table-top activities, finger movements, and progressive hand control exercises. Activities included placing the affected hand flat on a surface and lifting individual fingers, squeezing a softball, rolling a therapy ball with the thumb, picking up small objects, and completing puzzle-based tasks. The difficulty of activities was gradually increased according to the participant's performance. Shaping techniques, task repetition, rest intervals, and therapist feedback were used to improve motor learning, movement quality, and functional use of the affected limb. Each supervised session included exercise bouts of approximately 10–15 minutes with rest intervals of 5–10 minutes as required. A structured home program of approximately one hour per day was also prescribed, with exercises divided into shorter 7–10 minute segments to improve adherence and reduce fatigue (21-24).

Participants in Group B received Mirror Therapy for 10–30 minutes per session, five days per week, in addition to routine physiotherapy. During each session, a mirror was placed in the midsagittal plane so that the reflection of the unaffected upper limb created a visual illusion of normal movement in the affected limb. The therapy began with simple movements such as hand opening and closing, wrist and finger movements, and gradually progressed toward more functional and complex tasks, including gripping a ball, manipulating objects, and imitating activities of daily living. The reflected visual feedback was used to stimulate motor imagery, enhance sensorimotor integration, and promote neuroplastic changes associated with upper limb recovery (9,25). Participants were also instructed to perform a 10-minute home-based mirror exercise routine to reinforce the effects of supervised treatment. The primary outcome measures were upper extremity motor function and spasticity. Motor function was assessed using the Fugl-Meyer Assessment, a widely used and validated tool for evaluating motor impairment after stroke. Spasticity was assessed using the Modified Ashworth Scale, which is commonly used in clinical and rehabilitation settings to grade resistance during passive movement. These outcome measures were recorded at baseline and during follow-up assessments to determine within-group improvement over time and between-group differences in response to treatment.

Data were analyzed using SPSS version 24.0. Quantitative variables, including age and continuous outcome scores, were presented as mean and standard deviation. Categorical variables, including gender, were presented as frequency and percentage. The Kolmogorov–Smirnov test was applied to assess the normality of continuous data. For normally distributed variables, repeated-measures analysis of variance was used to examine within-group changes across different assessment points, while independent-samples t-tests were used to compare outcome differences between the two treatment groups. A p-value of less than 0.05 was considered statistically significant.

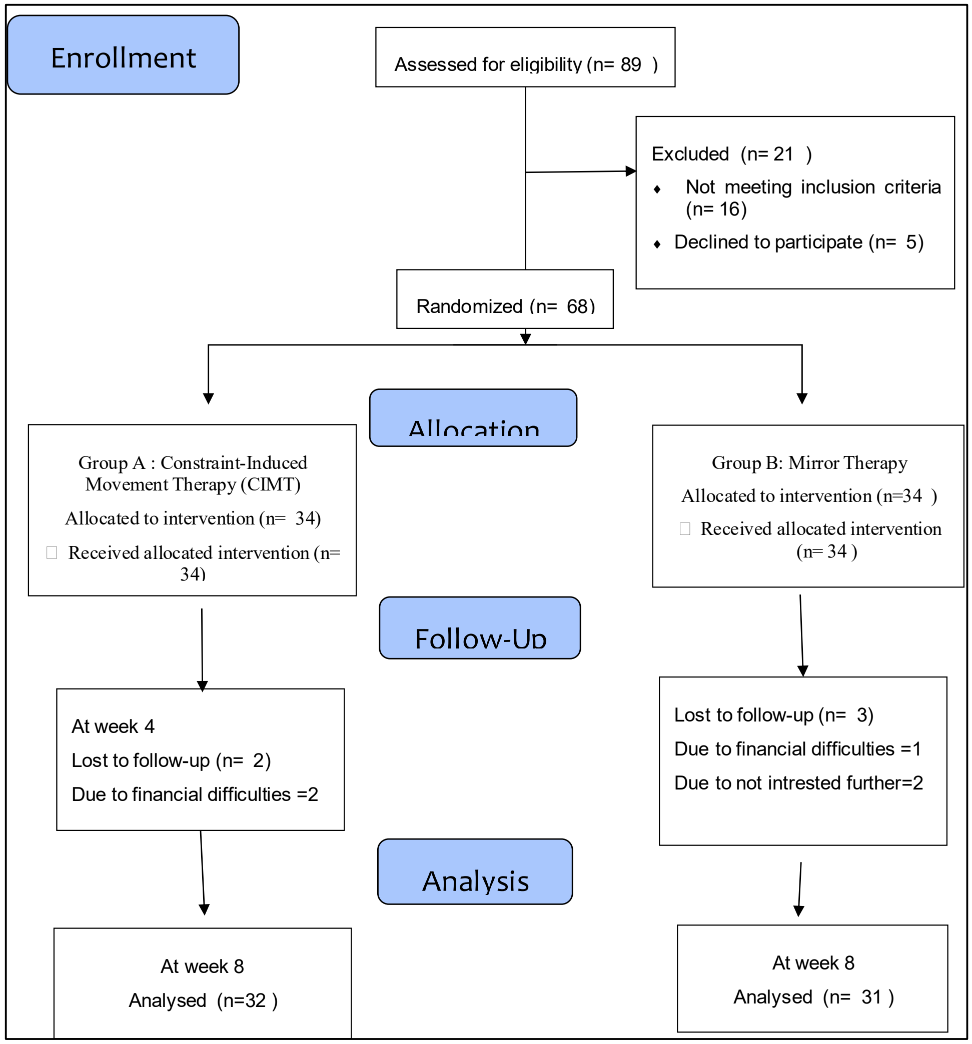


Figure Consort Flow Diagram

RESULTS

A total of 68 participants were included in the analysis, with 34 participants allocated to the Constraint-Induced Movement Therapy group and 34 participants allocated to the Mirror Therapy group. The mean age of participants in the Constraint-Induced Movement Therapy group was 53.65 ± 8.05 years, with an age range of 40 to 65 years. In the Mirror Therapy group, the mean age was 53.41 ± 7.14 years, with an age range of 41 to 65 years. The age distribution was comparable between the two groups. The Kolmogorov–Smirnov test showed that the Fugl-Meyer Assessment-Upper Extremity and Modified Ashworth Scale scores at baseline, 4th week, and 8th week were normally distributed, as all p-values were greater than 0.05. The categorical demographic distribution showed variation between the two groups. In the Constraint-Induced Movement Therapy group, females represented 76.5% of the participants, while males represented 23.5%. In the Mirror Therapy group, males represented 64.7% of the participants, while females represented 35.3%. Regarding the reported clinical category, traumatic brain injury was more frequent in the Constraint-Induced Movement Therapy group, accounting for 47.1% of participants, while ischemic and hemorrhagic cases were described as being similarly distributed across both groups. For education and occupation, the available data showed that 17.6% of participants in the Mirror Therapy group were graduates, 29.4% were retired, and 44.1% were reported as homeowners/homemakers. Detailed category-wise frequencies for all education, occupation, and stroke-type subgroups were not fully available in the provided results.

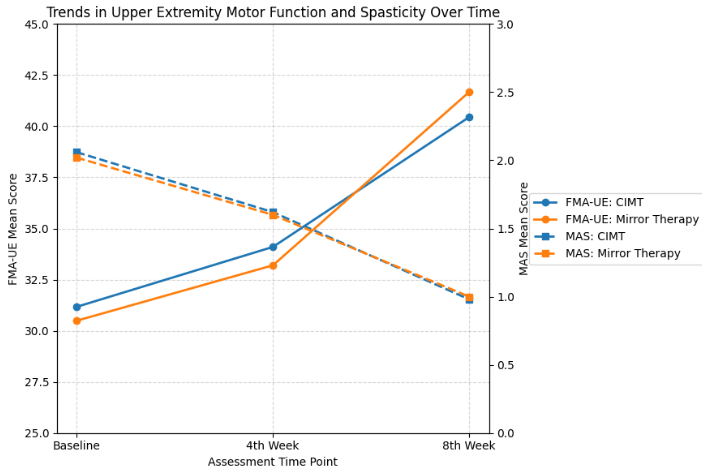
For spasticity, the Modified Ashworth Scale score decreased over time in both groups. In the Constraint-Induced Movement Therapy group, the mean score decreased from 2.06 ± 0.47 at baseline to 1.62 ± 0.49 at the 4th week and 0.98 ± 0.65 at the 8th week. In the Mirror Therapy group, the mean score decreased from 2.02 ± 0.65 at baseline to 1.60 ± 0.62 at the 4th week and 1.00 ± 0.42 at the 8th week. Repeated-measures analysis showed a statistically significant time effect for Modified Ashworth Scale scores across the assessment points, with $F = 52.51$ and $p < 0.001$. The assumption of sphericity was met for this outcome, with Mauchly's $W = 0.957$ and $p = 0.263$. Between-group comparisons showed no statistically significant difference at baseline, 4th week, or 8th week, with p-values of 0.816, 0.912, and 0.894, respectively. For upper extremity motor function, the Fugl-Meyer Assessment-Upper Extremity score increased over time in both groups. In the Constraint-Induced Movement Therapy group, the mean score increased from 31.17 ± 4.60 at baseline to 34.10 ± 5.02 at the 4th week and 40.45 ± 5.69 at the 8th week. In the Mirror Therapy group, the mean score increased from 30.49 ± 5.70 at baseline to 33.20 ± 4.83 at the 4th week and 41.68 ± 5.78 at the 8th week. Repeated-measures analysis showed a statistically significant time effect for Fugl-Meyer Assessment-Upper Extremity scores across the study period, with $F = 62.76$ and $p < 0.001$. The assumption of sphericity was also met for this outcome, with Mauchly's $W = 0.961$ and $p = 0.297$. Between-group comparisons showed no statistically significant difference at baseline, 4th week, or 8th week, with p-values of 0.590, 0.470, and 0.399, respectively. Overall, both groups showed statistically significant within-group changes from baseline to the 8th week in spasticity and upper extremity motor function. However, no statistically significant between-group difference was observed for either Modified Ashworth Scale or Fugl-Meyer Assessment-Upper Extremity scores at any measured time point.

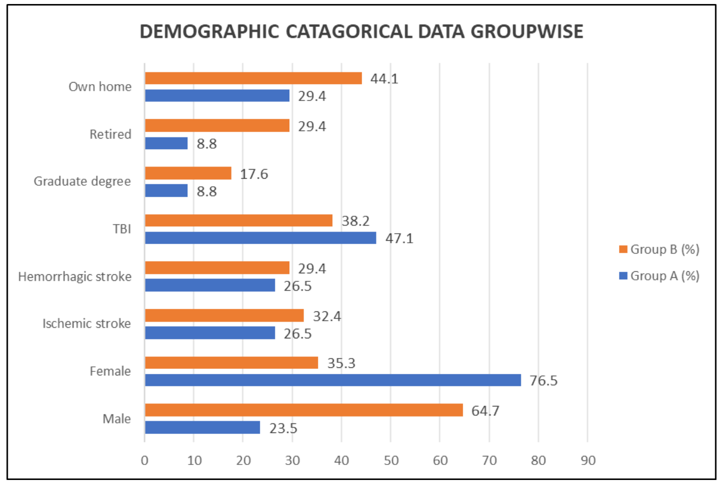
Table: Demographic table

Variable	**Group A: CIMT, n = 34**	**Group B: Mirror Therapy, n = 34**
Age, years, mean ± SD	53.65 ± 8.05	53.41 ± 7.14
Age range, years	40–65	41–65
Male, n (%)	8 (23.5%)	22 (64.7%)
Female, n (%)	26 (76.5%)	12 (35.3%)
Traumatic brain injury, n (%)	16 (47.1%)	Not reported
Ischemic stroke	Reported as similar between groups	Reported as similar between groups
Hemorrhagic stroke	Reported as similar between groups	Reported as similar between groups
Graduate education, n (%)	Not reported	6 (17.6%)
Retired, n (%)	Not reported	10 (29.4%)
Homeowner/homemaker, n (%)	Not reported	15 (44.1%)

Table: MAS and FMA-UE Outcomes with Statistical Analysis

Outcome	**Time Point**	**Group A (CIMT) Mean ± SD**	**Group B (Mirror Therapy) Mean ± SD**	**Within-Group (Time Effect)**	**Between-Group Difference**	**RM-ANOVA / Sphericity**
MAS (Spasticity)	Baseline	2.06 ± 0.47	2.02 ± 0.65	–	p = 0.816	Mauchly's W = 0.957, p = 0.263
	4th Week	1.62 ± 0.49	1.60 ± 0.62	p < .001	p = 0.912	RM-ANOVA: F = 52.51, p < .001
	8th Week	0.98 ± 0.65	1.00 ± 0.42	p < .001	p = 0.894	–
FMA-UE (Motor Function)	Baseline	31.17 ± 4.60	30.49 ± 5.70	–	p = 0.590	Mauchly's W = 0.961, p = 0.297
	4th Week	34.10 ± 5.02	33.20 ± 4.83	p < .001	p = 0.470	RM-ANOVA: F = 62.76, p < .001
	8th Week	40.45 ± 5.69	41.68 ± 5.78	p < .001	p = 0.399	–





DISCUSSION

The present study compared Constraint-Induced Movement Therapy and Mirror Therapy for improving hand function and reducing spasticity in patients with hemiparesis. The findings showed that both intervention groups demonstrated meaningful improvement over the 8-week treatment period, with increased Fugl-Meyer Assessment-Upper Extremity scores and reduced Modified Ashworth Scale scores. However, no statistically significant difference was observed between the two groups at baseline, 4th week, or 8th week. These findings suggested that both approaches had beneficial effects on upper limb motor recovery and spasticity reduction, but neither intervention showed clear superiority within the duration and conditions of this trial. The improvement observed in both groups was clinically relevant because hand function is one of the most important determinants of independence after hemiparesis. Reduced spasticity and improved voluntary control may support better grasp, release, object handling, self-care, dressing, feeding, and participation in daily activities. Constraint-Induced Movement Therapy may have improved recovery by encouraging repeated use of the affected limb and reducing learned non-use, whereas Mirror Therapy may have supported recovery through visual feedback, motor imagery, and activation of sensorimotor pathways. Although the two methods differed in therapeutic mechanism and intensity, the comparable outcomes in this study indicated that both interventions were capable of stimulating functional recovery when applied consistently during rehabilitation.

The findings were partly different from a randomized trial conducted among children with unilateral cerebral palsy, where Constraint-Induced Movement Therapy produced greater gains in grip strength and manual dexterity than mirror visual feedback, with reported dexterity improvement of 9.3% in the Constraint-Induced Movement Therapy group compared with 5.1% in the mirror visual feedback group (26). The difference between those findings and the present results may have been related to differences in age, diagnosis, baseline motor control, and neurological adaptability. Pediatric populations generally have greater developmental neuroplasticity, which may allow more pronounced responses to intensive constraint-based training. In contrast, the adult hemiparetic population in the present study appeared to respond positively to both therapies, without a clear between-group difference over the 8-week intervention period. The results were also consistent with evidence from a case-based investigation in which modified Constraint-Induced Movement Therapy improved upper limb coordination and range of motion by approximately 25% in a patient with incomplete spinal cord injury (27). Although that study supported the therapeutic value of Constraint-Induced Movement Therapy, its single-case design and absence of a comparison group limited direct comparison with the present trial. The current study added useful comparative evidence by including both Constraint-Induced Movement Therapy and Mirror Therapy groups, showing that similar functional gains could be achieved through a less restrictive, visually guided intervention as well as through a constraint-based approach.

A previous single-blinded randomized trial involving patients with stroke reported significant improvement in Fugl-Meyer Assessment-Upper Extremity scores after modified Constraint-Induced Movement Therapy, with mean gains of 11.6 points over four weeks (28). The present study also showed improvement in the Constraint-Induced Movement Therapy group, with a mean gain of 9.28 points from baseline to the 8th week. However, the Mirror Therapy group showed a slightly higher numerical gain of 11.19 points over the same period, although this difference was not statistically significant. This finding suggested that Mirror Therapy may provide motor benefits comparable to Constraint-Induced Movement Therapy in selected adult patients, particularly when delivered regularly over several weeks. However, the absence of a significant between-group difference prevented any firm conclusion regarding superiority. The present findings were not fully aligned with earlier comparative work in hemiparetic children, where Constraint-Induced Movement Therapy produced greater improvement in hand function than Mirror Therapy, with mean improvement scores of 10.2 and 6.3, respectively, on the Pediatric Motor Activity Log (29). This variation again highlighted the possible role of age, neurological condition, intervention intensity, and outcome tool selection in determining response to therapy. In pediatric populations, forced use and task repetition may produce larger measurable gains because of ongoing motor development and higher adaptability. In adults with hemiparesis, especially those with mixed clinical characteristics, both visual feedback-based training and forced-use training may produce similar recovery patterns.

Another comparative study in stroke survivors reported greater improvement after Constraint-Induced Movement Therapy than after Mirror Therapy, with Fugl-Meyer Assessment-Upper Extremity mean gains of 14.1 and 9.4, respectively (30). In contrast, the present study found comparable improvement between groups, with mean gains of 9.28 in the Constraint-Induced Movement Therapy group and 11.19 in the Mirror Therapy group. These differences may have resulted from variation in treatment intensity, intervention duration, baseline impairment level, chronicity of hemiparesis, therapist supervision, and participant characteristics. The inclusion of clinically heterogeneous cases may also have reduced the ability to detect a clear difference between the interventions. Evidence from another study comparing task-based Mirror Therapy with Constraint-Induced Movement Therapy in hemiplegic patients reported greater improvement in coordination and functional task speed after Constraint-Induced Movement Therapy, with hand dexterity gains of 15% compared with 8% after Mirror Therapy (31). The difference from the present findings may have been influenced by the task-specific nature of the earlier intervention. Task-specific training is strongly linked with functional motor relearning, and its structured inclusion may enhance the measurable effect of therapy. In the present study, both groups received routine physiotherapy and intervention-specific exercises, but the degree of task specificity and real-life functional practice may not have been equivalent across protocols. This may have contributed to the absence of significant between-group differences.

The findings were closely supported by a meta-analysis of studies involving subacute stroke patients, which concluded that both Mirror Therapy and Constraint-Induced Movement Therapy were effective for improving upper limb motor function and quality of life, without consistent evidence of superiority of one approach over the other (32). The present study followed a similar direction, as both groups improved significantly over time in motor function and spasticity, while between-group differences remained statistically non-significant. This agreement strengthened the view that both interventions may be useful components of upper limb rehabilitation, and that treatment choice may reasonably depend on patient tolerance, available resources, baseline motor ability, therapist expertise, and feasibility of implementation. The clinical implication of the present study was that Mirror Therapy may be considered a practical and less demanding alternative when Constraint-Induced Movement Therapy is difficult to apply because of fatigue, poor tolerance, limited compliance, or discomfort with prolonged restraint. At the same time, Constraint-Induced Movement Therapy remained a valuable intervention for patients who could tolerate intensive practice and had sufficient voluntary movement to participate actively. Since both interventions produced favorable outcomes, rehabilitation planning may benefit from an individualized approach rather than a single fixed protocol. A patient with better active movement and motivation may benefit from constraint-based task practice, while a patient with limited movement, pain, fear of movement, or low endurance may begin with Mirror Therapy and gradually progress toward more active task-oriented training.

The study had several strengths. It used a randomized clinical trial design, included equal group allocation, applied assessor blinding, and used established clinical outcome measures for upper limb motor impairment and spasticity. The repeated assessment at baseline, 4th week, and 8th week allowed observation of recovery trends over time rather than relying only on pre- and post-treatment scores. The comparison of two commonly used rehabilitation techniques also provided clinically useful information for physiotherapists working with patients who have hemiparesis. Several limitations were also present. The sample size was relatively small, which may have limited the power to detect smaller between-group differences. The study was conducted at a single center, reducing the generalizability of the findings to broader rehabilitation settings. The intervention period lasted eight weeks, and no follow-up assessment was performed after treatment completion, so the long-term sustainability of improvement remained unclear. The gender distribution was uneven between groups, which may have introduced imbalance in baseline participant characteristics. The treatment dose was also not fully equivalent, as Constraint-Induced Movement Therapy involved longer supervised practice and prolonged restraint, whereas Mirror Therapy was delivered for a shorter duration per session. This difference in treatment exposure may have influenced interpretation of comparative effectiveness.

Another important consideration was the clinical heterogeneity of the sample. If traumatic brain injury cases were included along with stroke-related hemiparesis, the study population may not have represented a purely post-stroke cohort. This issue should be clarified because recovery mechanisms, prognosis, and response to therapy may differ between stroke and traumatic brain injury. In addition, the study mainly focused on Fugl-Meyer Assessment-Upper Extremity and Modified Ashworth Scale scores. Although these measures were appropriate for motor impairment and spasticity, additional outcomes such as grip strength, hand dexterity, functional independence, quality of life, patient satisfaction, therapy adherence, and activity-based hand use would have provided a broader understanding of clinical recovery. Future studies should include larger multicenter samples with more balanced baseline characteristics and clearer diagnostic classification. Longer follow-up periods should be incorporated to determine whether treatment gains are maintained after completion of therapy. Future trials should also consider equalizing therapy dose between groups, documenting adherence to home programs, and including task-oriented functional training in both protocols. The use of additional outcome measures, such as grip strength, Box and Block Test, Nine-Hole Peg Test, Motor Activity Log, functional independence measures, and quality-of-life scales, may help capture changes that are more meaningful for daily life. Further research may also explore combined or sequential protocols in which Mirror Therapy is used initially to facilitate motor engagement, followed by Constraint-Induced Movement Therapy to strengthen active functional use of the affected hand.

CONCLUSION

The study concluded that both Constraint-Induced Movement Therapy and Mirror Therapy were effective in improving hand function and reducing spasticity among patients with hemiparesis. Although both interventions supported meaningful recovery, Mirror Therapy showed comparatively more favorable improvement in hand function within the intervention period, indicating its practical value as a simple, patient-friendly, and clinically useful rehabilitation approach. These findings suggest that Mirror Therapy may be considered an effective treatment option in upper limb rehabilitation, particularly where ease of application, patient tolerance, and functional recovery are important priorities.

AUTHOR CONTRIBUTION

Author	**Contribution**
Mahnoor Aleem	Conceptualization, Methodology, Formal Analysis, Writing - Original Draft, Validation, Supervision
Dr. Muhammad Sarfraz	Methodology, Investigation, Data Curation, Writing - Review & Editing
Abdul Mannan	Investigation, Data Curation, Formal Analysis, Software
Samia Khaliq	Software, Validation, Writing - Original Draft
Sania Zahra	Formal Analysis, Writing - Review & Editing
Iqra Waseem	Writing - Review & Editing, Assistance with Data Curation

REFERENCES

1. Burgess A, Chatfield MD, Hermith-Ramirez D, Jackman M, Thorley M, Reedman S, et al. Active upper-limb therapies for hand function, individual goal achievement, and self-care in children with cerebral palsy: A network meta-analysis. Dev Med Child Neurol. 2025;67(12):1543-53.
2. Liu M, Ushiba J. Brain-machine Interface (BMI)-based Neurorehabilitation for Post-stroke Upper Limb Paralysis. Keio J Med. 2022;71(4):82-92.
3. Vitrikas K, Dalton H, Breish D. Cerebral palsy: an overview. American family physician. 2020;101(4):213-20.
4. Bastola P, Singh P, Pinto D. A comparison of the effect of resistance training on upper extremity motor function, motor recovery, and quality of life in sub-acute stroke participants. Medical Journal of Dr DY Patil University. 2021;14(2):219-25.
5. Obman J. Comprehensive Rehabilitation of an Ipsilateral Stroke Patient: A Case Study: University of Iowa; 2020.
6. Rocha LSO, Gama GCB, Rocha RSB, de Barros Rocha L, Dias CP, Santos LLS, et al. Constraint induced movement therapy increases functionality and quality of life after stroke. Journal of Stroke and Cerebrovascular Diseases. 2021;30(6):105774.
7. Shamweel H, Gupta N. Constraint-induced movement therapy through telerehabilitation for upper extremity function in stroke. Journal of Neurorestoratology. 2024:100108.
8. Ceylan CM, Şen Eİ, Karaagac T, Şahbaz T, Yalıman A. Effect of Modified Constraint-Induced Movement Therapy on Upper Extremity Function for Stroke Patients with Right/Left Arm Paresis: A Single-Blind Randomized Controlled Trial. Ahi Evran Medical Journal. 2023;7(2):155-64.
9. Silpa C. Effectiveness of mirror therapy on upper and lower limb function among stroke patients with hemiparesis. Manipal Journal of Nursing and Health Sciences. 2021;7(1):5.
10. Paitial MPP, Sahu MR. Effects of Mirror Therapy (MT) and Modified Constraint Induced Movement Therapy on Improvement of Hand in Stroke Survivors: A Comparative Study. 2021.
11. Dave K. Effects of Mirror Therapy on Upper Extremity Functions among Hemiplegic patients: An Experimental Study. International Journal of Advances in Nursing Management. 2020;8(2):141-4.
12. de Sire A, Marotta N, Prestifilippo E, Agostini F, Parente A, Tasselli A, et al. Efficacy of Constraint-Induced Movement Therapy and mirror therapy in improving upper limb motor function and dexterity in post-stroke hemiparetic patients: a randomized controlled trial. Clin Ter. 2025;176(6):716-26.
13. Mohamed RA, Yousef AM, Radwan NL, Ibrahim MM. Efficacy of different approaches on quality of upper extremity function, dexterity and grip strength in hemiplegic children: a randomized controlled study. Eur Rev Med Pharmacol Sci. 2021;25(17):5412-23.
14. Abdel Ghafar MA, Abdelraouf OR, Alkhamees NH, Mohamed ME, Harraz EM, Seyam MK, et al. Enhancing Grip Strength and Manual Dexterity in Unilateral Cerebral Palsy: A Randomized Trial of Mirror Visual Feedback vs. Modified Constraint-Induced Movement Therapy. Brain Sciences. 2025;15(3):305.

15. Iswatun I, Wijayanti ES, Silvia RP. FAMILY NURSING CARE OF PHYSICAL MOBILITY DISORDERS IN PATIENT WITH POST STROKE IN BLULUK VILLAGE, LAMONGAN REGENCY. Journal of Vocational Nursing Vol. 2022;3(1):19-24.
16. Mostajeran M, Alizadeh S, Rostami HR, Ghaffari A, Adibi I. Feasibility and efficacy of an early sensory-motor rehabilitation program on hand function in patients with stroke: a pilot, single-subject experimental design. Neurol Sci. 2024;45(6):2737-46.
17. Xu J, Chen M, Wang X, Cai Z, Wang Y, Luo X. Global research hotspots and trends in constraint-induced movement therapy in rehabilitation over the past 30 years: a bibliometric and visualization study. Front Neurol. 2024;15:1375855.
18. Albishi AM. How does combining physical therapy with transcranial direct stimulation improve upper-limb motor functions in patients with stroke? A theory perspective. Ann Med Surg (Lond). 2024;86(8):4601-7.
19. Bai Z, Fong KN, Zhang JJ, Chan J, Ting K. Immediate and long-term effects of BCI-based rehabilitation of the upper extremity after stroke: a systematic review and meta-analysis. Journal of neuroengineering and rehabilitation. 2020;17:1-20.
20. Bisen R, Ganvir S. Mapping the Comparative Effectiveness of Modified Constraint-Induced Movement Therapy, Hand-Arm Bimanual Intensive Training, and Mirror Therapy for Upper Extremity Rehabilitation in Children With Hemiplegic Cerebral Palsy: A Scoping Review. Cureus. 2025;17(12):e98440.
21. 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: California State University, Fresno; 2020.
22. Gandhi DB, Sterba A, Khatter H, Pandian JD. Mirror therapy in stroke rehabilitation: current perspectives. Therapeutics and clinical risk management. 2020:75-85.
23. Madbouly ME, Olama KA, Omar T, El Fakharany MS. Modified constraint-induced movement therapy versus mirror therapy on affected hand functions in hemiparetic children. Annals of Clinical and Analytical Medicine. 2021;12(8):924-8.
24. Aabedi A, Mashiach D, Fraix MP, Agrawal DK. Most Effective Interventions for Improving Upper Extremity Function in Patients with Hemiparesis. Cardiol Cardiovasc Med. 2026;9(6):504-11.
25. Karaganova I, Mindova S. Neuroplasticity after stroke: Adaptive and maladaptive mechanisms in evidence-based rehabilitation. J Stroke Cerebrovasc Dis. 2026;35(6):108634.
26. Travanichakul S, Kijpaisalratana N, Kitjawijit T, Petcharunpaisan S, Chutinet A, Suwanwela NC. Prevalence and predictive factors of progression in pure motor, ataxic hemiparesis and mixed sensorimotor lacunar syndrome. Neurology Asia. 2023;28(1).
27. Türkmen C, Konca M, Yetim B. Prioritization of neurologic rehabilitation interventions by ELECTRE-III analysis in subacute stroke patients. Acta Neurol Belg. 2023;123(1):181-9.
28. Tekin F, Kavlak E. Short and long-term effects of whole-body vibration on spasticity and motor performance in children with Hemiparetic cerebral palsy. Perceptual and Motor Skills. 2021;128(3):1107-29.
29. Preetha K, Vimala U, Kamalakannan M. A study to compare task-based mirror therapy versus constraint induced movement therapy for hand function in hemiplegic subjects. Biomedicine. 2021;41(3):665-8.
30. Yang FA, Lee TH, Huang SW, Liou TH, Escorpizo R, Chen HC. Upper limb manual training for children with cerebral palsy: A systematic review and network meta-analysis of randomized controlled trials. Clin Rehabil. 2023;37(4):516-33.
31. Antoniadou E, Vassilopoulou P, Marini K, Patouha M, Tsoukanelis S, Panagea E, et al. Use of the modified constraint induced movement therapy protocol to improve function of the predominant arm on a patient with incomplete spinal cord injury. American Journal of Physical Medicine & Rehabilitation. 2022;101(4):e62-e4.
32. Carson RG, Hayward KS. Using mechanistic knowledge to appraise contemporary approaches to the rehabilitation of upper limb function following stroke. J Physiol. 2025;603(3):635-50.