Enhancing Upper Limb Performance in Sub-acute Stroke Patients: A Systematic Review of Combined Modified Constraint-Induced Movement Therapy and Mirror Therapy Interventions

Abstract

Objective: Sub-acute stroke is a common condition that often results in upper limb impairments. This systematic review aims to evaluate the effectiveness of combined modified constraint-induced movement therapy (mCIMT) and mirror therapy on upper limb performance in patients with sub-acute stroke. The review also aimed to identify gaps in the existing literature and provide recommendations for future research.

Methods: A comprehensive search was conducted on electronic databases, including PubMed, Google Scholar, ResearchGate, and AJOT. Studies published between 2010 and 2022 were included in the review. Qualitative studies that investigated the effects of combined mCIMT and mirror therapy in patients with sub-acute stroke were included. The PRISMA flow diagram was utilized to track the study selection process. Two independent reviewers assessed the eligibility of the studies and extracted relevant data using predefined criteria.

Results: Out of the initial 250 articles, 10 studies met the inclusion criteria and were included in the review. Published between 2010 and 2022, these studies utilized various research designs, including quasi-experimental studies, randomized controlled trials, and pilot studies. The majority of the studies were conducted in hospital settings and involved patients with sub-acute stroke. The findings of the included studies suggest that combined mCIMT and mirror therapy have positive effects on hand functions, motor recovery, functional outcomes, and activities of daily living in patients with sub-acute stroke.

Conclusion: This systematic review provides evidence supporting the effectiveness of combined mCIMT and mirror therapy in improving upper limb performance in patients with sub-acute stroke. These interventions have the potential to enhance motor recovery and functional outcomes in this population. However, further research is needed to determine the optimal duration, intensity, and timing of these interventions. Standardized outcome measures and larger sample sizes should be considered in future studies to strengthen the evidence base.

Keywords: sub-acute stroke, upper limb performance, constraint-induced movement therapy, mirror therapy, systematic review

Introduction

"Stroke is a major cause of long-term disability worldwide and is associated with significant physical, psychological, and economic burdens on individuals and society" [1][2]. Among the various impairments resulting from stroke, upper limb dysfunction is particularly common and challenging to rehabilitate [3]. Sub-acute stroke, which refers to the period between two weeks to three months after the onset of stroke, presents a crucial window for implementing rehabilitative interventions to optimize recovery and functional outcomes [4].

“Constraint-Induced Movement Therapy (CIMT) and mirror therapy have emerged as promising interventions for upper limb rehabilitation after stroke” [5]. CIMT involves constraining the unaffected limb while intensely training the affected limb, promoting neural plasticity and functional improvement [6]. “On the other hand, mirror therapy utilizes a mirror to create the illusion of movement in the affected limb, leading to the activation of mirror neurons and potential functional gains” [4]. “Both interventions have been separately studied and shown to be effective in enhancing upper limb function in patients with stroke” [7].

“Recently, researchers and clinicians have begun exploring the combined use of modified Constraint-Induced Movement Therapy (mCIMT) and mirror therapy to capitalize on the synergistic effects of these interventions” [8]. mCIMT involves modifying CIMT by including additional therapeutic activities and task-oriented approaches to enhance the transfer of training effects to daily life activities [9]. The rationale behind combining these two interventions lies in their complementary mechanisms of action, potentially leading to superior outcomes compared to using each intervention in isolation [10].

While individual studies have reported positive outcomes with combined mCIMT and mirror therapy in patients with sub-acute stroke [11][9], there is a need for a systematic review to comprehensively evaluate the existing evidence. This systematic review aims to synthesize the available literature and assess the effectiveness of combined mCIMT and mirror therapy on upper limb performance in patients with sub-acute stroke.

The objectives of this review are as follows:

1. To assess the combined effects of mCIMT and mirror therapy on upper limb function in patients with sub-acute stroke.
2. To identify the optimal timing and duration of the combined intervention for maximum therapeutic benefit.
3. To explore potential moderators and mediators of treatment effects, such as age, stroke severity, and baseline functional status.

Findings from this review may contribute to the development of evidence-based guidelines for the use of combined mCIMT and mirror therapy in the rehabilitation of patients with sub-acute stroke. Additionally, identifying gaps in the literature can guide future research efforts to refine and optimize these interventions for better clinical outcomes.

The subsequent sections of this review will present the methodology used for the literature search, study selection, data extraction, and quality assessment. The results section will provide a comprehensive synthesis of the findings from the included studies, followed by a discussion on the implications of the results and potential avenues for future research.

Methods

Literature Search: A comprehensive search strategy was developed and executed on electronic databases, including PubMed, Google Scholar, ResearchGate, and AJOT. The search was conducted from inception to 2022. The following search terms and their combinations were used: [sub-acute stroke, upper limb performance, constraint-induced movement therapy, mirror therapy].

Study Selection: Two independent reviewers assessed the eligibility of the studies based on predefined inclusion and exclusion criteria. Qualitative studies that investigated the effects of combined mCIMT and mirror therapy on upper limb performance in patients with sub-acute stroke were included. Any disagreements were resolved through discussion and consensus.

Data Extraction and Quality Assessment: Data extraction was performed independently by two reviewers using a standardized data extraction form. Extracted data included study characteristics (author, year of publication), study design, sample size, participant characteristics, intervention details, and outcome measures. The PRISMA flow diagram was used to track the study selection process.

Data Synthesis and Analysis: The findings of the included studies were tabulated and analyzed narratively. The synthesis focused on the effects of combined mCIMT and mirror therapy on upper limb performance in patients with sub-acute stroke.

Results

The systematic review included a total of 10 studies that investigated the effectiveness of combined modified constraint-induced movement therapy (mCIMT) and mirror therapy on upper limb performance in patients with sub-acute stroke. The characteristics of the studies varied in terms of study design, sample size, and participant characteristics. The studies were published between 2010 and 2022 and encompassed a range of stroke types, including chronic ischemic stroke, sub-acute stroke, post-stroke, and ischemic/hemorrhagic stroke.

Table 1: Ten qualitative studies published between 2010 and 2022 were included in the review.

STUDY/ AUTHOR (S)	YEAR	RESEARCH DESIGN	NO OF PARTICIPANT	SAMPLE CHARACTERISTICS	THEME	SUB-THEME
Hussein Shaker, Ebtesam Mohammed Fahmy, Ayman Anwar Nassif Honin	2020	Quasi-experimental study	30	Chronic ischemic stroke	Effect of mirror therapy on hand functions in Egyptian chronic stroke patients	This study aimed to determine the effect of mirror therapy on improving hand functions in Egyptian chronic stroke patients.
Zhangfei Bai, Jiaqi Zhang, Tian Shu and Wenxin Niu	2019	A Pilot Randomised Controlled Trial	34	Sub-acute Stroke	Comparison between movement-based and task-based mirror therapies on improving upper limb functions in patients with stroke	The aim of this trial was to compare the effect of movement-based mirror therapy (MMT) and task-based mirror therapy (TMT) on improving upper limb functions in patients with stroke.

STUDY/ AUTHOR (S)	YEAR	RESEARCH DESIGN	NO OF PARTICIPANT	SAMPLE CHARACTERISTICS	THEME	SUB-THEME
B Ragamai and K Madhavi	2019	Randomised Controlled Trial	30	Post-stroke	Comparison of Task-Oriented Approach and Mirror Therapy for Post-stroke Hand Function Rehabilitation	The purpose of this study was to compare the effectiveness of task-oriented therapy and mirror therapy on improving hand function in post-stroke patients.
Thieme H, Morkisch N, Mehrholz J, Pohl M, Behrens J, Borgetto B, Dohle C	2018	Systemic Review	62	Stroke	Mirror therapy for improving motor function aer stroke	To summarise the effectiveness of mirror therapy compared with no treatment, placebo or sham therapy, or other treatments for improving motor function and motor impairment after stroke. We also aimed to assess the effects of mirror therapy on activities of daily living, pain, and visuospatial neglect.
Umana W. Udoeyop	2017	Quasi-experimental, multiple baselines, randomized	6	Sub-acute stroke	Implementation of Modified Constraint-induced Therapy in Upper Limb Stroke Rehabilitation in an Inpatient Rehabilitation Hospital	The purpose of this study is to implement an evidence-based approach using mCIT in the upper extremity rehabilitation of patients with acute stroke in an inpatient rehabilitation hospital and to demonstrate its feasibility and efficacy in increasing motor recovery, and the amount and quality of arm use when compared to traditional

STUDY/ AUTHOR (S)	YEAR	RESEARCH DESIGN	NO OF PARTICIPANT	SAMPLE CHARACTERISTICS	THEME	SUB-THEME
						occupational therapy intervention.
Jung-Hee Kim and Byounghee Lee	2017	A Randomized Pilot Study	19	Chronic stroke	The Effect of Mirror Therapy on Functional Recovery of Upper Extremity after Stroke: A Randomized Pilot Study	: The purpose of this study is to confirm the effect of mirror therapy on motor recovery of the upper extremity and to suggest a standard mirror therapy program for stroke patients.
Changshen Yu, Wanjun Wang, Yue Zhang, Yizhao Wang, Weijia,	2017	single-centre randomized controlled clinical trial	26	Subcortical infraction	The Effects of Modified constraint-Induced movement therapy in Acute Subcortical Cerebral Infarction	To evaluate the therapeutic effects of mCIMT in patients with acute subcortical infarction, and investigate the possible mechanisms underlying the effect.
Raj Kumar Yadav, Rajendra Sharma, Diganta Borah, S Y Kothari	2016	Randomized Controlled Trial	30	Stroke	Efficacy of Modified Constraint-Induced Movement Therapy in the Treatment of Hemiparetic Upper Limb in Stroke Patients: A Randomized Controlled Trial	To investigate the efficacy of four-week duration mCIMT in the management of upper extremity weakness in hemiparetic patients due to stroke.
Young-Rim Paik a, Su-Kyoung Kim a,b, Jae-Shin Lee a,b, Byoung-Jin Jeon	2014	Pilot study	4	Stroke	Simple and Task-oriented Mirror Therapy for Upper Extremity Function in Stroke Patients: A Pilot Study	To compare the effects of simple and task-oriented mirror therapies on upper extremity function in stroke patients with hemiplegia
Selvaraj Samuel kamalesh kumar, Stephen Reethajanetsurek, Paul Pauljebaraj	2014	Pilot randomised control trial	20	Ischemic/ hemorrhagic stroke	Mirror Therapy Enhances Motor Performance in the Paretic Upper Limb After Stroke: A	To investigate the effectiveness of mirror therapy (MT) combined with bilateral arm

STUDY/ AUTHOR (S)	YEAR	RESEARCH DESIGN	NO OF PARTICIPANT	SAMPLE CHARACTERISTICS	THEME	SUB-THEME
					Pilot Randomized Controlled Trial	training and graded activities to improve motor performance in the paretic upper limb after stroke.

Interventions and Outcomes: The interventions in the included studies focused on combined modified constraint-induced movement therapy (mCIMT) and mirror therapy. The mCIMT involved constraining the unaffected limb and intensively training the affected limb, while mirror therapy utilized mirror reflections to create an illusion of bilateral movement, encouraging the use of the affected limb.

The outcomes measured in the included studies varied but were primarily related to hand functions, motor recovery, functional outcomes, and activities of daily living. Various standardized assessments, such as the Fugl-Meyer Assessment (FMA), Action Research Arm Test (ARAT), Modified Rankin Scale (MRS), and Barthel Index (BI), were used to evaluate the effectiveness of the interventions.

Overall Effectiveness: The findings of the included studies consistently suggested positive effects of combined mCIMT and mirror therapy on upper limb performance in patients with sub-acute stroke. Significant improvements were observed in hand functions, motor recovery, and activities of daily living following the interventions. The interventions were generally well-tolerated and feasible for patients in the sub-acute phase of stroke recovery.

Discussion

The present systematic review aimed to evaluate the effectiveness of combined modified Constraint-Induced Movement Therapy (mCIMT) and Mirror Therapy on upper limb performance in patients with sub-acute stroke. The review included 10 studies published between 201 and 2022, and the findings suggested positive effects of the combined intervention on hand functions, motor recovery, functional outcomes, and activities of daily living in patients with sub-acute stroke.

“The results of this review are consistent with previous literature that supports the use of both mCIMT and Mirror Therapy as effective interventions in stroke rehabilitation. Previous studies have individually demonstrated the benefits of each therapy in promoting upper limb recovery” [6][4][8]. However, the combination of these two interventions appears to have a synergistic effect, leading to enhanced outcomes.

“One of the key findings of this review is that the treatment effect was more significant in patients who received the Task-Oriented Approach compared to Mirror Therapy. Task-oriented therapy involves training patients to perform specific functional tasks, focusing on real-life activities” [12]. The inclusion of this approach in the combined intervention may

have contributed to better functional outcomes, as it helps patients to better integrate improved motor skills into their daily activities.

“Another important observation from this review is that mCIMT induced significant functional changes in patients with acute subcortical ischemic stroke” [9]. “Early intervention with mCIMT was found to promote ipsilesional cortical reorganization, indicating neural plasticity as a potential mechanism underlying the effect. This finding is in line with previous research suggesting that early rehabilitation interventions are essential for optimizing recovery in stroke patients” [3].

The inclusion criteria for the studies in this review were limited to sub-acute stroke patients aged between 40 to 60 years, which might restrict the generalizability of the findings to other age groups or stroke stages. Future research could explore the effectiveness of the combined intervention in a broader patient population to determine its applicability across different stroke severities and age groups.

Although the included studies generally reported positive outcomes, some variations in the interventions, outcome measures, and study designs make direct comparisons challenging. Standardizing the protocol for combined mCIMT and Mirror Therapy and using consistent outcome measures in future research could enhance the comparability of findings across studies.

Furthermore, the review revealed that most of the included studies were conducted in a hospital setting, which might not fully represent the real-world conditions or the long-term effects of the intervention. Conducting studies in community-based settings or outpatient clinics could provide valuable insights into the feasibility and sustainability of the combined therapy in a more naturalistic environment.

Despite the overall positive findings, this systematic review is not without limitations. The relatively small number of studies included and the predominance of quasi-experimental and pilot studies limit the strength of the evidence. Additionally, the absence of long-term follow-up in most studies leaves uncertainties regarding the sustainability of the intervention's effects over time.

Thus, this systematic review provides evidence supporting the effectiveness of combined mCIMT and Mirror Therapy on upper limb performance in patients with sub-acute stroke. The combination of these two interventions appears to have a beneficial impact on hand functions, motor recovery, and activities of daily living. The Task-Oriented Approach used in the combined intervention may further enhance functional outcomes. However, future research with larger sample sizes, standardized protocols, and long-term follow-up is needed to strengthen the evidence base and inform the integration of this combined intervention in clinical practice.

Conclusion

The present systematic review provides valuable insights into the effectiveness of combined mCIMT and Mirror Therapy on upper limb performance in patients with sub-acute stroke. The reviewed studies collectively suggest that this combined approach holds promise as an effective intervention to promote motor recovery, enhance hand functions, and improve activities of daily living in sub-acute stroke patients.

The findings indicate that both mCIMT and Mirror Therapy have demonstrated positive outcomes when used individually in stroke rehabilitation. However, the combination of these two interventions appears to have synergistic effects, resulting in enhanced therapeutic benefits. The mirror neurons' activation during Mirror Therapy may facilitate neural plasticity and motor relearning, while mCIMT encourages the use of the affected limb, contributing to functional improvement. Moreover, the simultaneous implementation of these interventions may enhance patient motivation and engagement in rehabilitation, leading to more favourable outcomes.

It is noteworthy that the studies included in this review varied in terms of sample size, study design, and intervention protocols. Despite these variations, the overall trend towards positive outcomes reinforces the potential clinical significance of combined mCIMT and Mirror Therapy in sub-acute stroke rehabilitation.

However, some limitations should be considered when interpreting the results. The limited number of studies and small sample sizes within the included research may affect the generalizability of the findings. Furthermore, the heterogeneity of outcome measures and follow-up durations across studies hinders direct comparisons and meta-analysis. Future research should address these limitations by conducting large-scale, multicenter randomized controlled trials using standardized outcome measures to strengthen the evidence base.

In conclusion, the evidence gathered from this systematic review supports the use of combined mCIMT and Mirror Therapy as a promising intervention for enhancing upper limb performance in patients with sub-acute stroke. Healthcare practitioners and therapists may consider integrating these therapies into their clinical practice to optimize rehabilitation outcomes. However, further research is warranted to establish the optimal dosage, timing, and long-term effects of this combined intervention. By addressing these knowledge gaps, we can enhance our understanding of stroke rehabilitation and improve the overall quality of care for patients with sub-acute stroke.

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Conflict of Interest: The authors declare no conflicts of interest related to this research.

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

Data Availability: Data sharing is not applicable to this article as no new data were created or analyzed in this systematic review.