

Efficacy of mirror therapy combined with task-oriented training on upper limb function after stroke: A systematic review and meta-analysis



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ABSTRACT

Background: Mirror therapy (MT) and task-oriented training therapy (TOT) are rehabilitation methods used to improve upper limb function in post-stroke patients. However, evidence regarding the efficacy of combining these two interventions is still limited. This study aimed to evaluate the efficacy of MT with TOT on upper limb function recovery in stroke patients.

Methods: The study search was conducted systematically based on the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) 2020 guidelines. Randomized controlled trials (RCTs) that used a combination of MT with TOT in the rehabilitation of stroke patients were included in the analysis. The primary outcomes evaluated included improved upper extremity function, as assessed using the Fugl-Meyer Assessment-Upper Limb (FMA-UL), and manual dexterity. The risk of bias was assessed using the Cochrane Risk of Bias (RoB) tool. The pooled mean difference was used as a point estimate using Review Manager v5.4.1.

Results: Eight RCTs (n=465) were included in the analysis. Most studies applied the intervention five days per week with a therapy duration of generally four weeks. The results of the forest plot analysis showed a significant difference in the mean FMA-UL score between the stroke patient group receiving MT with TOT and the control group (MD 6.79; 95%CI 2.95–10.63; p<0.01). However, no significant difference was found in the mean FMA-UL score between the MT with TOT group and the control group (MD 3.02; 95%CI -1.29–7.33; p=0.17).

Conclusion: This study showed that the combination of MT with TOT significantly improved upper extremity motor impairment in post-stroke patients.

Keywords: Fugl-Meyer assessment-upper limb, mirror therapy, stroke, task-oriented training, upper limb.

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INTRODUCTION

Stroke remains a major global health problem and a leading cause of long-term disability and mortality worldwide. According to the Global Burden of Disease (GBD) study, stroke prevalence nearly doubled from 271 million in 1990 to 523 million in 2019, and stroke became the third leading cause of death in 2021.¹ Upper limb impairment is among the most disabling sequelae after stroke. Approximately 33–80% of patients experience hemiparesis, and many develop persistent upper limb dysfunction that limits movement, daily activities, and social participation.^{2,3}

Recovery of upper limb function after stroke is closely related to neuroplasticity,

the brain's ability to reorganize neural networks in response to injury and experience. Neuroplastic mechanisms, including synaptic remodeling and cortical reorganization, provide the biological basis for motor recovery.⁴ Rehabilitation strategies that use activity-dependent plasticity, particularly intensive, repetitive, and task-specific practice, can improve motor relearning and functional recovery.⁵ Repetitive task training has shown benefits for upper extremity function and functional activity performance, but conventional rehabilitation may still have limited transfer to real-life function when treatment intensity, task relevance, or patient engagement is inadequate.^{6,7}

Mirror therapy (MT) is a non-invasive rehabilitation approach that uses mirror

visual feedback (MVF) to create the illusion of movement in the affected limb by reflecting movements of the unaffected limb. This visual illusion is thought to activate motor-related cortical regions involved in movement planning and execution, thereby facilitating motor relearning.⁸ Neurophysiological studies have shown that MT may induce cortical reorganization toward the affected hemisphere, supporting its role in post-stroke motor recovery.⁸ The previous Cochrane review found that MT improved motor function, motor impairment, and activities of daily living (ADL) after stroke compared with control interventions.⁹ Additionally, a recent meta-analysis further reported improvements in upper

limb motor and hand function, particularly when MT was delivered frequently (≥ 5 sessions/week) and over longer durations.¹⁰ However, MT alone may not fully optimize transfer to complex, real-world arm use. Some MT protocols rely on relatively simple or repetitive movements that may not adequately represent meaningful functional tasks, potentially limiting generalizability to daily activities.¹¹ This limitation supports combining MT with rehabilitation approaches that explicitly emphasize functional task performance.

Task-oriented training (TOT) is a functional rehabilitation approach that targets motor recovery through repeated practice of meaningful, goal-directed tasks relevant to daily life.¹² Task-oriented training (also referred to as task-specific or goal-directed training) is designed to enhance motor learning and neuroplasticity through context-relevant practice.¹² A previous systematic review involving 692 adult stroke survivors reported strong to moderate evidence that activity-based TOT improved upper limb motor function, motor performance, and ADL performance.¹³ A previous RCT has also shown clinically significant improvements in upper extremity outcomes, including Fugl-Meyer Assessment-Upper Extremity (FMA-UE), Wolf Motor Function Test (WMFT), and hand function, compared with conventional exercise programs.¹⁴ Task-oriented training-based ADL training has likewise been associated with improvements in upper limb function, manual dexterity, ADL performance, and quality of life in chronic stroke survivors.¹⁵ Given their potentially complementary mechanisms, combining MT and TOT may enhance upper limb recovery after stroke. Mirror therapy may prime the motor system through visual feedback, while TOT may reinforce motor learning through repetitive practice of meaningful tasks. Available studies suggest benefit from this combined approach, including improvements in motor function, coordinated movement, use of the affected arm, independence in daily activities, and quality of life.^{16,17} A previous meta-analytic evidence also indicates that combined MT interventions (MT plus other rehabilitation modalities) may be superior to rehabilitation therapy alone for upper

Table 1. Study eligibility qualifications based on the population, intervention, comparison, outcome, and study design (PICOS)

PICOS	Inclusion criteria	Exclusion criteria
Population (P)	Adult stroke patients (≥ 18 years) with upper limb dysfunction.	Studies involving paediatric patients and stroke patients without upper extremity dysfunction. Animal or in vitro studies are excluded.
Intervention (I)	Stroke patients who received a combination of MT with TOT	Studies using TOT without MT are complex multimodal interventions whose effects cannot be separated
Comparison (C)	Stroke patients are not receiving the combination of MT with TOT (no intervention, standard care).	Studies without a comparison/control group or those not differentiating outcomes between MT with TOT and non-MT combined with TOT.
Outcome (O)	Improved upper extremity function, such as: Motor function of the arms and hands, Ability to perform functional activities, Coordination, and strength of the upper extremities	Studies not reporting upper extremity function outcomes. Studies only reported non-functional outcomes: quality of life only, cognitive activity only. Outcomes were not measured or did not use clear instruments.
Study Design (S)	RCTs, published in the last 10 years (with extractable data on efficacy of MT and TOT on upper extremity motor function in stroke patients).	Prospective or retrospective cohort studies, case-control studies, review articles, editorials, commentaries, conference abstracts without full data, duplicate studies, or studies with insufficient outcome data for pooled analysis.
MT, mirror therapy; TOT, task-oriented training; RCTs, randomized controlled trials		

extremity motor recovery. Nevertheless, evidence specifically addressing MT combined with TOT remains limited and methodologically heterogeneous, and a clear consensus has not yet been established.¹⁸ Therefore, this systematic review and meta-analysis aimed to evaluate the efficacy of mirror therapy combined with task-oriented training (MT with TOT) on upper limb function after stroke.

METHODS

Study Design

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guideline was used in this systematic review and meta-analysis. This paper aimed to evaluate the efficacy of MT combined with TOT on upper limb function after stroke by

synthesizing current evidence from the literature. The study has been registered in the International Prospective Register of Systematic Reviews (PROSPERO) under the registration number CRD420261321758.

Search strategy

A comprehensive literature search was conducted in four online databases: PubMed, ScienceDirect, the Cochrane Library, and ProQuest from 1st February 2026 to 7th February 2026. The search strategy used a combination of relevant Boolean Operator including ("Stroke") AND ("Mirror Therapy") AND/OR (Task-Oriented Training) AND ("Upper Limb Function"). Search parameters were adjusted to suit each database's indexing system. Additionally, the reference lists of identified articles were manually reviewed

to identify other eligible studies not identified through the database search.

Eligibility criteria

Studies were included if they involved adult stroke patients (≥ 18 years) with upper limb dysfunction. Eligible interventions included MT combined with TOT. Comparators consisted of subjects who received no intervention or other standard care. Studies were required to report efficacy outcomes, namely improved upper extremity function, such as motor function of the arms and hands, ability to perform functional activities (ADL), coordination, and strength of the upper extremity. Only RCTs, published within the last ten years, were considered. Studies were excluded if they involved paediatric patients without upper extremity dysfunction, were animal or in vitro studies, lacked a comparison group, did not report efficacy, or were cohort studies, cross-sectional studies, review articles, editorials, conference abstracts without complete data, duplicate studies, or studies with insufficient outcome data for pooled analysis. **Table 1** presents comprehensive eligibility requirements derived from the PICOS framework.

Screening and Data Extraction

A standardized form was used by two independent reviewers to extract study characteristics, ensure consistency, and minimize bias. Key information, including author name, year of publication, study location, and study design, was systematically recorded. Data regarding sample size, patient profile, and intervention details were also extracted. Primary outcomes included upper extremity motor impairment, while secondary outcomes included manual dexterity. Additionally, study-specific variables, such as equipment and the task given, were collected to facilitate analysis. Key findings from each study were synthesized and tabulated to facilitate qualitative assessment and quantitative meta-analytic pooling.

Risk of bias assessment

The quality of included studies was assessed using the Risk of Bias 2 (RoB2) tool, which allowed studies to be classified as low risk, having some concerns, or

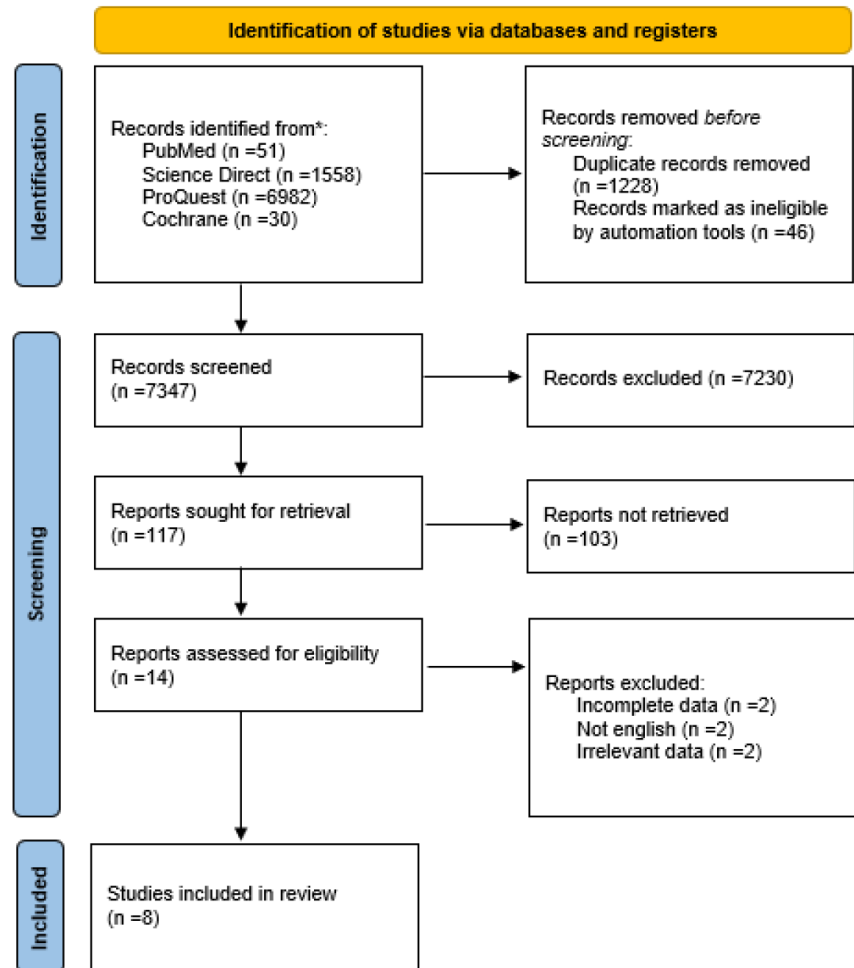


Figure 1. Preferred reporting items for systematic reviews and meta-analyses (PRISMA) flowchart

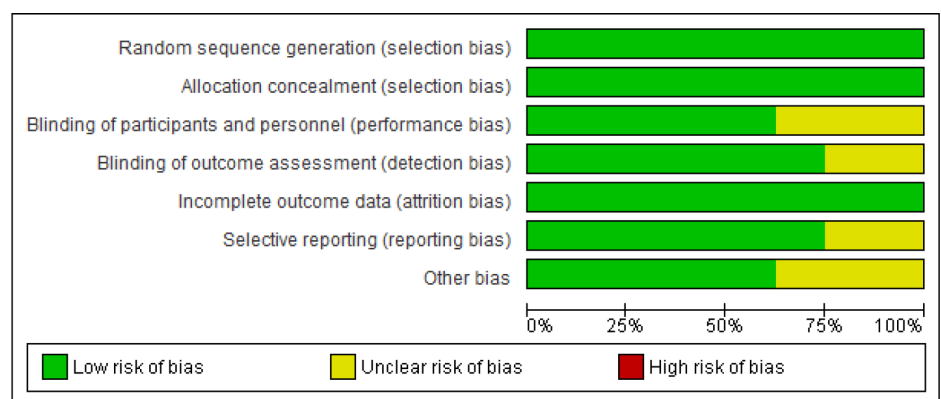


Figure 2. Risk of bias summary of included studies

high risk. Duplicate publications were removed before assessment. Discrepancies identified during screening of titles, abstracts, and full-text articles were resolved by consensus among reviewers to ensure methodological rigor.

Data analysis

Continuous variables were analyzed using either a fixed-effects or random-effects model, depending on the presence of heterogeneity, and pooled effect estimates were expressed as mean difference with corresponding 95% confidence intervals

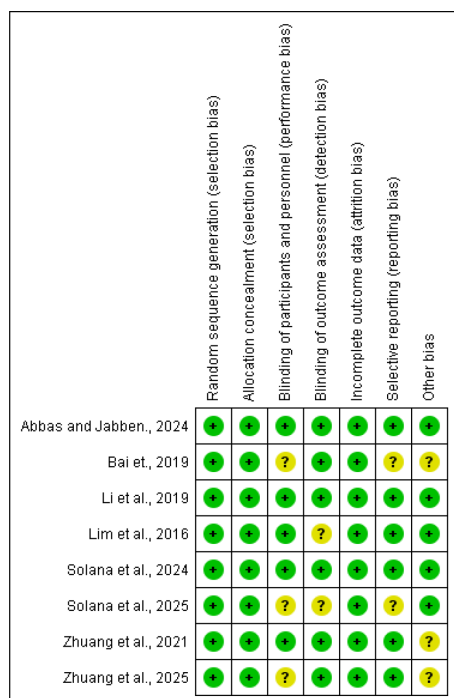


Figure 3. Risk of bias of included studies

(CI). Heterogeneity was quantified using the Higgins I^2 statistic, with a value of 0% indicating no heterogeneity and a value above 50% indicating substantial heterogeneity. Publication bias was assessed visually through funnel plot analysis. All statistical calculations were performed using Review Manager (RevMan) version 5.4.1, and a p -value ≤ 0.05 was considered statistically significant.

RESULTS

Literature search

A literature search of four electronic databases yielded 8,621 studies, comprising 30 studies from Cochrane, 51 studies from PubMed, 6,982 studies from ProQuest, and 1,558 studies from ScienceDirect. A total of 1,274 studies were removed, including 1,228 duplicates and 46 studies excluded through automated tools, resulting in 7,347 unique studies screened at the title and abstract stage. A total of 7,230 studies were deemed irrelevant and excluded, leaving 117 studies for full-text search. Full-text access for 103 studies was unsuccessful, leaving 14 studies for eligibility assessment. Six studies were excluded from these 14 due to incomplete data in two studies, English-language articles in two studies, and irrelevant

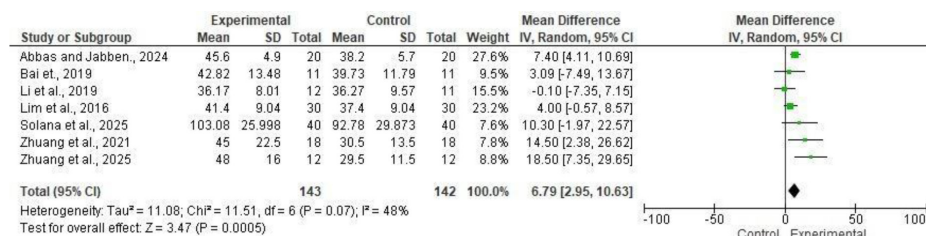


Figure 4. Forest plot analysis on Fugl-Meyer assessment upper limb (FMA-UL) post-intervention

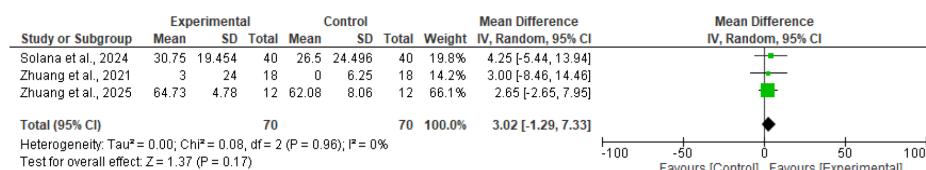


Figure 5. Forest plot analysis on manual dexterity post-intervention

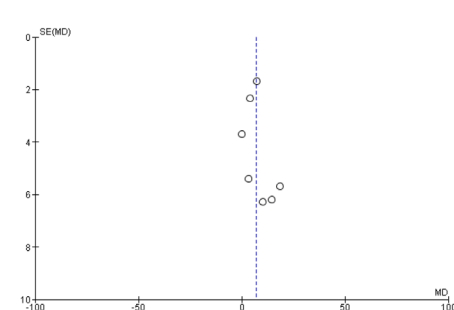


Figure 6. Funnel plot analysis on Fugl-Meyer assessment upper limb (FMA-UL) post-intervention.

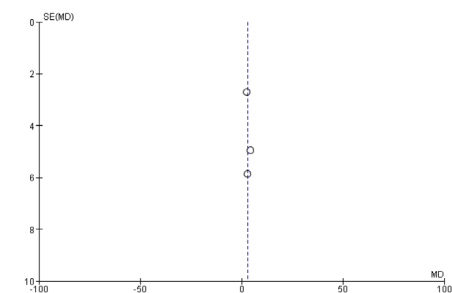


Figure 7. Funnel plot analysis on manual dexterity post-intervention

results in two studies. Eight studies met all inclusion criteria and were included in the systematic review and meta-analysis.

Study characteristics

Data synthesis was performed from eight RCTs. These studies were conducted in five countries across Asia and Europe and involved over 465 participants, with sample sizes ranging from 23 to 128 per study (Table 2). The study population included stroke patients with upper extremity dysfunction. Subject characteristics in the included studies were predominantly male, stroke type was primarily ischemic, and the lesion site was relatively balanced with a predilection for left-sided lesions. The intervention used was MT combined with TOT. The MT system was implemented using a portable mirror box, a table-mounted mirror, or a camera-based digital mirror system to support upper extremity motor recovery.

Tasks were performed individually with gradually increasing difficulty, including bilateral cooperative tasks, functional activities, and activities based on activities of daily living. Session duration ranged from 20 to 90 minutes, with a frequency of implementation generally 5 days per week, and the intervention duration in most studies was 4 weeks (Table 3).

Study outcomes

The outcomes of eight studies were evaluated to assess the effects of MT combined with TOT in stroke patients with upper extremity dysfunction. The primary outcome most frequently assessed was upper extremity motor impairment, while secondary outcomes were manual dexterity. Several studies also reported on quality of life, sensory function, ADL, and functional independence. Improvements in outcomes were generally found in the MT with TOT intervention

Table 2. Population characteristics

Authors, years	Location	Population				
		Total sample	Age (years)	Male	Left-lesion side	Ishemic stroke type
Zhuang et al., 202121	China	36	I: 54.0 ± 24.0 C: 58.0 ± 22.75●	66.6%	52.7%	33.3%
Li et al., 201933	China	23	54.57 ± 10.52Δ	56.5%	43.4%	52.1%
Solana et al., 202434	Spain	128	68.92 ± 11.79Δ	58.3%	51.7%	91.5%
Bai et., 201935	Italy	34	54.36 ± 11.56Δ	73.5%	44.1%	73.5%
Zhuang et al., 202536	China	24	52.75 ± 14.51Δ	83.3%	45.8%	37.5%
Solana et al., 202516	Spain	120	68.92†	58.3%	51.6%	92.5%
Lim et al., 201637	Korea	60	I: 65.3 C: 64.5†	65%	51.6%	31.6%
Abbas and Jabben, 202438	Pakistan	40	I: 59.4 ± 8.2 C: 58.7 ± 7.9Δ	57.5%	NR	NR

Δ, data presented in mean ± standard deviation; ●, data presented in median ± quartile range; †, data presented in mean; %, percentage. NR, not reported

group, with significant improvements in upper extremity motor impairment and functional outcomes, along with a feasibility profile. Primary outcomes were reported to significantly improved after the intervention compared to the control group. Improvements were also reported in secondary outcomes, including manual dexterity, ADL, and functional independence, such as the Functional Independence Measure (FIM) and Modified Barthel Index (MBI). Improvements in quality of life were also reported in one study, particularly related to spasticity, range of motion, and pain. The benefits of MT with TOT on motor recovery and functional performance in stroke patients with upper extremity dysfunction can be inferred from these findings (Table 4).

Risk of bias

The quality of the included studies ranged from low to moderate risk of bias in all evaluated areas, including selection bias, performance bias, detection bias, attrition bias, reporting bias, and other potential biases. No studies were rated high risk of bias, indicating overall strong methodological quality across the included studies and strengthening the validity of their findings (Figures 2 and 3).

Quantitative analysis

The analysis for Fugl-Meyer Assessment Upper Limb (FMA-UL) post-intervention

outcomes included seven studies, with a total of 143 participants receiving MT with TOT and 142 participants in the comparator group. The results of forest plot analysis showed a significant difference in mean FMA-UL in stroke patients who received MT with TOT compared to the control group (MD 6.79; 95%CI 2.95 to 10.63; $p < 0.01$), with moderate heterogeneity ($I^2 = 48\%$; $p = 0.07$) (Figure 4).

The analysis for manual dexterity post-intervention outcomes included three studies, with a total of 70 participants receiving MT with TOT and 70 participants in the comparator group. The results of forest plot analysis showed no significant difference in mean FMA-UL in stroke patients who received MT with TOT compared to the control group (MD 3.02; 95%CI -1.29 to 7.33; $p = 0.17$), with low heterogeneity ($I^2 = 0\%$; $p = 0.96$) (Figure 5).

Publication bias

Visual inspection of the funnel plot reveals mild asymmetry that may indicate publication bias, the tendency for studies with positive or significant findings to be published more frequently than studies with negative or null results. This qualitative observation raises concerns about the strength and representativeness of the available evidence. Statistical tests for funnel plot asymmetry are needed to strengthen the assessment.

The limited number of included studies limits the feasibility and reliability of this quantitative method, preventing conclusive conclusions about the degree of publication bias (Figure 6).

DISCUSSION

This study demonstrates that the MT with TOT intervention provides significant improvements in upper extremity motor outcomes compared to control treatments. This consistent effect is also supported by moderate inter-study variation. Therefore, the combined results can be considered quite stable despite differences in intervention design and implementation. The relatively equal size of the intervention and control groups in most studies contributed to the consistency of findings across studies. Manual dexterity outcomes did not show convincing differences. Therefore, the benefits of the intervention on fine dexterity aspects still require further evidence.

Functional impairment due to stroke is often permanent and can interfere with various aspects of physical function, such as cognitive, perceptual, visual, and emotional functions. To reduce these long-term effects, physical therapists apply various rehabilitation approaches to stroke patients. One of the physiotherapy interventions developed is a combination of MT with TOT, which is based on the principles of the nervous system. This approach aims to retrain movement

Table 3. Intervention characteristics

Authors, years	Intervention					
	Equipment	Task	Task selection	Session	Frequency	Follow-up duration
Zhuang et al., 202120	Mirror-based system	Bilateral cooperative tasks: holding a ball, grabbing and rolling a cylinder, stacking towels, lifting a stick, and pushing a sanding board	2–3 tasks based on patient condition	30 minutes	5 days/week, and around 4 hours/day for 4 weeks	Pre, 2 weeks, 4 weeks
Li et al., 201931	Portable mirror box	Task-oriented functional activities (e.g., picking handset, placing items); non-task-oriented movements (forearm pronation/supination, finger flexion/extension); Functional training (e.g., chopping, pouring)	Therapist-guided, individual-based on patient condition impairment/goals	90 min (45 min mirror box training with 45 min functional training)	3 days/week for 4 weeks	Pre, 4 weeks
Solana et al., 202432	Mirror between arms; chair and table setup	Functional tasks simulating ADL, IADL, work, and leisure activities	Increasing difficulty based on performance	30 minutes	5 days/week for 5 weeks	Pre, after 20 sessions (5 weeks), 3 months after
Bai et., 201933	Table, chair, mirror perpendicular to patient	Customary upper limb functional training and ADL training.	Individualized and increasing difficulty	30 minutes	5 days/week for 4 weeks	1 day pre, 1 day post
Zhuang et al., 202534	Camera-based mirror	Bilateral cooperation task: e.g grasping the ball.	Therapists-assisted, synchronous hand movement	30 minutes	5 days/week for 4 weeks	2 weeks, 4 weeks
Solana et al., 202516	Chair and mirror	Activities: meal preparation, handling garments, and personal hygiene tasks	Progressive difficulty	1 hour	5 days a week	Pre, post-20 sessions, 3 months
Lim et al., 201635	Mirror 35 cm×35 cm	1 week simple movement (Forearm/wrist movement), 2 weeks simple movement (Finger/tapping), 3 weeks, Simple task (Pick, flip, put), 4 weeks complex task (drawing)	Progressive task from simple to complex over 4 weeks	20 Minutes	5 days a week	4 weeks
Abbas and Jabben., 202436	NS	NS	Individualized-tailored repetitive tasks to enhance daily functional capabilities	45 minutes	5 days a week	NS

ADL, activities of daily living; IADL, instrumental activities of daily living; NS, not specified

patterns and brain perception through task-oriented training, in which patients perform a series of movements with their healthy side of the body while watching the reflection of these movements in a mirror, creating the illusion that the affected limb is also moving, thereby stimulating brain reorganization.^{19,20}

Functional improvement of the upper extremities in post-stroke patients with MT with TOT therapy is based on the utilization of neuroplasticity theory. Neuroplasticity is the ability of the

nervous system to adapt to internal and external stimuli through changes in neural structure, function, and connectivity.²¹ In the eight studies analyzed, MT with TOT therapy was administered at an average frequency of five times per week for 30 minutes per session, and then evaluated after four weeks. The combination of MT with TOT was proven effective in improving the function and performance of the affected upper extremity and enhancing patients' ability to perform activities of daily living.²²

The size of mirrors used for MT with TOT in the eight studies analyzed showed considerable variation, indicating that there is currently no standard regarding mirror dimensions. However, it is recommended that mirrors be placed in the midsagittal plane so that reflections of healthy limbs appear to replace the position of the affected limbs. This arrangement is important for producing an optimal visual illusion, which is believed to play a role in enhancing neuroplasticity and motor function recovery in post-stroke patients.⁹

Table 4. Study outcomes

Authors, years	Outcome		Main finding
	Primary	Secondary	
Zhuang et al., 202120	Upper extremity motor impairment: FMA-UL	Motor and daily function: BBT, FIM	Associated Mirror Therapy (AMT) was feasible and safe, with no adverse events. Both groups showed significant post-intervention improvements in FMA-UL and FIM ($p < 0.001$). Compared with the control group, AMT showed greater improvements in FMA-UL at 2 weeks ($P = 0.018$) and 4 weeks ($P = 0.001$), FIM improvements at 2 weeks ($P = 0.041$) and 4 weeks ($P = 0.003$). ²⁰
Li et al., 201931	Upper extremity motor impairment: FMA-UE. Sensation impairment: rNSA. Self-perceived quality of life and multidimensional stroke recovery: SIS 3.0	Arm and hand function during 13 real-life bilateral tasks: CAHAI. Use of the affected upper extremity: MAL	Mirror therapy (MT) showed a potential trend toward improvements in temperature sensation and SIS 3.0 score. It also shows a trend for greater improvement in MAL.
Solana et al., 202432	Upper limb function: ARAT	Manual dexterity: BBT. Quality of affected arm use (MAL-30). Functional independence in ADL (FIM-FAM). Quality of life (SS-QoL)	Compared with the control group, both experimental groups (MT with TOT and CTE with TOT) showed statistically significant improvements in upper limb function and fine and gross motor skills, quantity and quality of affected arm use, functional independence in activities of daily living, and quality of life, with no significant differences between the two experimental groups and maintenance of gains at long-term follow-up. ³²
Bai et., 201933	Function of the upper limb: FMA-UE and WMFT	Muscle tone of the affected: MAS. Activity of daily: MBI	MT group showed greater improvement in FMA-UE than other therapies, and there was a significant time-by-group interaction. No significant interaction effect was noted in WMFT, hand grip strength, MAS, and MBI. ³³
Zhuang et al., 202534	Hand dexterity: BBT_I	BBT_C, functions of upper limb (FMA_UE), FIM	AMT improves affected upper limb and hand motor impairment, and hand dexterity, as shown by higher FMA and FIM scores than the control group ($p < 0.001$). ³⁴
Solana et al., 202516	Functions of the upper limb: FMA-UE	-	There was statistically significant improvement in the overall functionality of the upper limb in these patients, except for range of motion and pain in the experimental groups compared to the control. ¹⁶
Lim et al., 201635	Functions of the upper limb: FMA and Brunnstrom. Activities of daily: MBI	-	The FMA score and MBI improved significantly in both groups ($p < 0.001$), with greater recovery in the MT group. No significant between-group difference in Bruunstrom stage. ³⁵
Abbas and Jabben., 202436	Functions of the upper limb: FMA-UE. Improvements in functional performance: ARAT	Spasticity (Modified Ashworth Scale) range of motion, and daily living skills (Barthel Index)	There was a significant interaction effect between time and group for both FMA-UE and ARAT scores. ³⁶

AMT, associated mirror therapy; ARAT, action research arm test; BBT, box and block test; BBT_C, contralesional box and block test; BBT_I, ipsilesional box and block test; CAHAI, Chedoke arm and hand activity inventory; CTE, cognitive therapeutic exercise; FIM, functional independence measure; FIM-FAM, functional independence measure – functional assessment measure; FMA-UE, Fugl-Meyer assessment upper extremity; FMA-UL, Fugl-Meyer assessment upper limb subscale; MAL, motor activity log; MAS, modified ashworth scale; MBI, modified barthel index; MT, mirror therapy; RNSA, revised Nottingham sensory assessment; SIS 3.0, stroke impact scale 3.0; SS-qol, stroke-specific quality of life scale; TOT, task-oriented training; WMFT, wolf motor function test.

Mirror therapy is a rehabilitation method that utilizes visual illusions and real-time visual feedback to retrain motor function in patients with hemiparesis and improve functional ability.²³ Although the neurophysiological mechanism is not yet fully understood, several hypotheses explain the effects of MT, including activation of the mirror neuron system,

recruitment of ipsilateral motor pathways, and activation of motor networks through observation of the illusion of paretic limbs moving normally.²⁴ These visual illusions stimulate the premotor area, which plays a role in post-stroke motor recovery, increase the activity of the primary motor area, and activate the right superior occipital gyrus and superior temporal gyrus. A previous

study reported that this process involves the activation of mirror neurons in the frontotemporal area, superior temporal gyrus, and sensorimotor cortex.¹⁹

Task-oriented training itself is an effective rehabilitation approach for improving motor skills and neural plasticity in patients with central nervous system injuries. This study found that

TOT was implemented progressively, starting with simple movements and then increasing to more complex movements, with a focus on functional activities that represent common everyday movements. Task-oriented training for post-stroke patients is generally carried out in stages, with the level of difficulty adjusted to the patient's functional capacity. This approach aligns with the principles of motor learning and neuroplasticity mechanisms, as motor learning occurs most optimally when exercises are given with progressively increasing difficulty.^{25,26} This approach emphasizes meaningful and relevant functional activities that are relevant to daily life, thereby promoting the transfer of skills to real-life activities and utilizing neural plasticity through the recruitment of brain areas surrounding the lesion or other intact areas. An effective TOT program is supported by an appropriate level of challenge, progressive adaptation, and active patient involvement. Recovery of upper extremity function through TOT occurred through a motor learning process that optimizes voluntary control, particularly in the wrist and fingers, accompanied by increased activity and reorganization of the sensorimotor and primary motor areas that contributed to the recovery of paretic arm function.^{14,27}

The findings of this meta-analysis indicate that the addition of MT to TOT is associated with greater improvements in upper extremity motor outcomes compared to TOT alone. Interpretation of these findings requires careful consideration of methodological variations across studies, although the combined effect could potentially provide additional benefits. Overall, the reported study results are also relatively consistent with previous evidence suggesting that MT can contribute to motor recovery after stroke.⁹ Mirror therapy is thought to operate through mirror visual feedback, based on a mechanistic perspective, which creates the visual illusion of movement in the affected limb. Previous studies reported that this visual feedback may be associated with increased activation in motor-related cortical areas and possible cortical reorganization.⁸

Recent neurophysiological studies have also reported the potential recruitment of ipsilateral motor pathways during

mirror-based interventions, although the precise influence of these pathways on functional recovery remains to be determined.²⁸ Motor recovery through TOT is enhanced through repetitive, goal-oriented functional training. This intervention is thought to support use-dependent plasticity and motor relearning processes. The emphasis on task-specific, high-repetition, periodized training is also recognized in current stroke rehabilitation guidelines to facilitate functional improvement.²⁹ Additional stimulation may be provided by the MT with TOT combination through visual feedback, which could enhance the engagement of motor networks before or during task-specific training. Alignment with motor priming models in neurorehabilitation may also be indicated by this hypothesis, as preparatory cortical activation is thought to enhance the response to subsequent training.³⁰

Although this study shows that the combination of MT with TOT can improve upper extremity motor outcomes in post-stroke patients, limitations of this study include the limited number of studies, the availability of manual dexterity outcome data which only comes from a small number of studies so that the certainty of the effect on fine dexterity aspects cannot be ascertained, the duration of intervention and follow-up is generally short, variations in intervention protocols between studies on the type of mirror therapy device, task components, intensity, and session duration that could potentially affect the consistency of the effect, and the assessment of publication bias that cannot be confirmed quantitatively due to the small number of studies and the asymmetry of the funnel plot which is only indicative.

CONCLUSION

This study demonstrated that the combination of MT with TOT improved upper extremity motor impairment in post-stroke patients compared to a control group. No significant differences were found in manual dexterity outcomes, so evidence of improvements in fine dexterity remains limited. Future research is needed through randomized controlled trials with larger sample sizes, standardized

MT with TOT protocols for device type, task components, intensity, and session duration, and longer follow-up to assess the sustainability of effects and transfer to activities of daily living, along with consistent reporting of manual dexterity outcomes and more reliable evaluation of publication bias.

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CONFLICT OF INTEREST

None declared.

ETHICAL CONSIDERATION

None declared.

AI STATEMENT

No artificial intelligence (AI) tool was used to formulate the research question, design the study, perform literature screening, extract data, assess risk of bias, conduct statistical analyses, interpret the findings, or generate the scientific conclusions. All substantive scientific content, methodological decisions, data verification, and final manuscript revisions were completed by the authors, who take full responsibility for the accuracy, integrity, and originality of this work.

AUTHOR CONTRIBUTIONS

SH, AS initiated the study, collected and curated the data, performed the analysis, and wrote the initial draft; IWDWA designed the methodology, supervised the study, validated the findings, and edited the manuscript; NMNN supervised the study, validated the findings, and edited the manuscript. All authors reviewed and approved the final manuscript and take responsibility for the integrity and accuracy of the work.

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REFERENCES

1. Feigin VL, Abate MD, Abate YH, Abd ElHafeez S, Abd-Allah F, Abdelalim A, Abdelkader

- A, Abdelmasseh M, Abd-Elsalam S, Abdi P, Abdollahi A. Global, regional, and national burden of stroke and its risk factors, 1990–2021: a systematic analysis for the Global Burden of Disease Study 2021. *The Lancet Neurology*. 2024 Oct 1;23(10):973-1003.
2. Hirayama K, Matsuda M, Teruya M, Fuchigami T, Morioka S. Trends in amount of use to upper limb function in patients with subacute stroke: a cross-sectional study using segmental regression analysis. *BMC neurology*. 2023 Dec 4;23(1):429.
3. Senadheera I, Hettiarachchi P, Haslam B, Nawaratne R, Pollack M, Hillier S, Nilsson M, Alahakoon D, Carey LM. Combined Individual Experience and Accelerometry Measurement of Upper Limb Use in Daily Activities in Real Time After Stroke. *Sensors*. 2025 Dec 2;25(23):7330.
4. Du W, Shen J, Su T. Neuroplasticity in stroke rehabilitation: harnessing Brain's adaptive capacities for enhanced recovery. *Studies in Social Science & Humanities*. 2023;2(11):50-8.
5. Bhaskare GM. Neuroplasticity-based physiotherapy approaches in stroke rehabilitation: A systematic review. *J Nov Physiother Rehabil*. 2025 Oct;9(2):033-5.
6. French B, Thomas LH, Coupe J, McMahon NE, Connell L, Harrison J, Sutton CJ, Tishkovskaya S, Watkins CL. Repetitive task training for improving functional ability after stroke. *Cochrane database of systematic reviews*. 2016(11):CD006073.
7. Xiong J, Wang JT, Lin S, Xie BY. Advances in hemiplegia rehabilitation: modern therapeutic interventions to enhance activities of daily living. *Frontiers in Neurology*. 2025 Mar 28;16:1555990.
8. Michielsen ME, Selles RW, Van Der Geest JN, Eckhardt M, Yavuzer G, Stam HJ, Smits M, Ribbers GM, Bussmann JB. Motor recovery and cortical reorganization after mirror therapy in chronic stroke patients: a phase II randomized controlled trial. *Neurorehabilitation and neural repair*. 2011 Mar;25(3):223-33.
9. Thieme H, Morkisch N, Mehrholz J, Pohl M, Behrens J, Borgetto B, Dohle C. Mirror therapy for improving motor function after stroke. *The Cochrane database of systematic reviews*. 2018 Jul 11;2018(7):CD008449.
10. Saragih ID, Priyanti RP, Batubara SO, Lee BO. Effects of mirror therapy on upper limb motor function of patients with stroke: A systematic review and meta-analysis of randomized controlled trials. *Clinical Rehabilitation*. 2025 Jan;39(1):23-34.
11. 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. *Journal of physical therapy science*. 2016;28(2):483-7.
12. McDermott A. Task-oriented training—upper extremity. *Stroke Engine*. 2014.
13. Lee CY, Howe TH. Effectiveness of activity-based task-oriented training on upper extremity recovery for adults with stroke: a systematic review. *American Journal of Occupational Therapy*. 2024 Mar;78(2):302-10.
14. Thant AA, Wanpen S, Nualnetr N, Puntumetakul R, Chatchawan U, Hla KM, Khin MT. Effects of task-oriented training on upper extremity functional performance in patients with sub-acute stroke: a randomized controlled trial. *Journal of physical therapy science*. 2019;31(1):82-7.
15. Alsubiheen AM, Choi W, Yu W, Lee H. The effect of task-oriented activities training on upper-limb function, daily activities, and quality of life in chronic stroke patients: a randomized controlled trial. *International journal of environmental research and public health*. 2022 Oct 29;19(21):14125.
16. Fernández-Solana J, Vélez-Santamaría R, Moreno-Villanueva A, Álvarez-Pardo S, González-Bernal J, Santamaría-Peláez M, González-Santos J. Effect of mirror therapy versus cognitive therapeutic exercise on upper limb functionality, autonomy, and poststroke quality of life: a randomized trial. *American Journal of Occupational Therapy*. 2025 Sep;79(5):971-84.
17. Bondoc S, Booth J, Budde G, Caruso K, DeSousa M, Earl B, Hammerton K, Humphreys J. Mirror therapy and task-oriented training for people with a paretic upper extremity. *American Journal of Occupational Therapy*. 2018 Jan;72(2):236-44.
18. Luo Z, Zhou Y, He H, Lin S, Zhu R, Liu Z, Liu J, Liu X, Chen S, Zou J, Zeng Q. Synergistic effect of combined mirror therapy on upper extremity in patients with stroke: a systematic review and meta-analysis. *Frontiers in neurology*. 2020 Apr 2;11:155.
19. Jaafar N, Che Daud AZ, Ahmad Roslan NF, Mansor W. Mirror therapy rehabilitation in stroke: a scoping review of upper limb recovery and brain activities. *Rehabilitation research and practice*. 2021;2021(1):9487319.
20. Zhang Y, Wenyan LY, Jiabao LI. Effects of mirror therapy combined with task-oriented training on limb function recovery in stroke patients with hemiplegia. *Journal of Sichuan University (Medical Sciences)*. 2023 Sep 20;54(5):1046.
21. Joshua AM. Neuroplasticity. In: *Physiotherapy for Adult Neurological Conditions*. StatPearls Publishing; 2022. p. 1–30.
22. Gonzalez-Santos J, Soto-Camara R, Rodriguez-Fernández P, Jimenez-Barrios M, Gonzalez-Bernal J, Collazo-Riobo C, Jahouh M, Bravo-Anguiano Y, Trejo-Gabriel-Galan JM. Effects of home-based mirror therapy and cognitive therapeutic exercise on the improvement of the upper extremity functions in patients with severe hemiparesis after a stroke: A protocol for a pilot randomised clinical trial. *BMJ open*. 2020 Sep;10(9):e035768.
23. Ventoulis I, Gkouma KR, Ventouli S, Polyzogopoulou E. The role of mirror therapy in the rehabilitation of the upper limb's motor deficits after stroke: narrative review. *Journal of Clinical Medicine*. 2024 Dec 20;13(24):7808.
24. Madhoun HY, Tan B, Feng Y, Zhou Y, Zhou C, Yu L. Task-based mirror therapy enhances the upper limb motor function in subacute stroke patients: a randomized control trial. *European journal of physical and rehabilitation medicine*. 2020 Mar 25;56(3):265-71.
25. Christiansen L, Larsen MN, Madsen MJ, Grey MJ, Nielsen JB, Lundbye-Jensen J. Long-term motor skill training with individually adjusted progressive difficulty enhances learning and promotes corticospinal plasticity. *Scientific reports*. 2020 Sep 24;10(1):15588.
26. Afridi A, Malik AN, Rathore FA. Task oriented training for stroke rehabilitation: a mini review. *JPMA. The Journal of the Pakistan Medical Association*. 2023 Nov;73(11):2295-7.
27. Thant AA, Wanpen S, Nualnetr N, Puntumetakul R, Chatchawan U, Hla KM, Khin MT. Effects of task-oriented training on upper extremity functional performance in patients with sub-acute stroke: a randomized controlled trial. *Journal of physical therapy science*. 2019;31(1):82-7.
28. Zhang K, Ding L, Wang X, Zhuang J, Tong S, Jia J, Guo X. Evidence of mirror therapy for recruitment of ipsilateral motor pathways in stroke recovery: A resting fMRI study. *Neurotherapeutics*. 2024 Mar 1;21(2):e00320.
29. Winstein CJ, Stein J, Arena R, Bates B, Cherney LR, Cramer SC, Deruyter F, Eng JJ, Fisher B, Harvey RL, Lang CE. Guidelines for adult stroke rehabilitation and recovery: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke*. 2016 Jun;47(6):e98-169.
30. Stoykov ME, Madhavan S. Motor priming in neurorehabilitation. *Journal of neurologic physical therapy: JNPT*. 2015 Jan;39(1):33.
31. Li YC, Wu CY, Hsieh YW, Lin KC, Yao G, Chen CL, Lee YY. The priming effects of mirror visual feedback on bilateral task practice: a randomized controlled study. *Occupational Therapy International*. 2019;2019(1):3180306.
32. Fernández-Solana J, Álvarez-Pardo S, Moreno-Villanueva A, Santamaría-Peláez M, González-Bernal JJ, Vélez-Santamaría R, González-Santos J. Efficacy of a Rehabilitation Program Using Mirror Therapy and Cognitive Therapeutic Exercise on Upper Limb Functionality in Patients with Acute Stroke. In: *Healthcare*. 2024 Mar;12(5):569.
33. Bai Z, Zhang J, Zhang Z, Shu T, Niu W. Comparison between movement-based and task-based mirror therapies on improving upper limb functions in patients with stroke: a pilot randomized controlled trial. *Frontiers in neurology*. 2019 Mar 26;10:288.
34. Zhuang J, Cheng B, Shu B, Ding L, Jia J. Effect of associated mirror therapy on the less affected hand in patients with subacute stroke: a pilot randomized controlled trial. *Journal of Stroke and Cerebrovascular Diseases*. 2025 Aug 1;34(8):108374.
35. Lim KB, Lee HJ, Yoo J, Yun HJ, Hwang HJ. Efficacy of mirror therapy containing functional tasks in poststroke patients. *Annals of rehabilitation medicine*. 2016 Aug 24;40(4):629.
36. Abbas A, Jabeen SR. Efficacy of combined task-oriented training and mirror therapy in post-stroke upper limb recovery: a randomized controlled trial. *Journal of Health and Rehabilitation Research*. 2024 Dec 31;4(4):1-4.



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