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Original Article

Effectiveness of Task-Oriented Training versus Conventional Physiotherapy on Gross Motor Function, Balance, and Functional Independence in Children with Spastic Cerebral Palsy: A Randomized Controlled Trial

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ABSTRACT

Background: Persistent upper-limb impairment after stroke restricts independence and participation in daily activities. Mirror therapy provides augmented visual feedback that may enhance task-oriented motor practice. Objective: To compare mirror therapy combined with task-oriented training with task-oriented training alone for improving upper-limb motor function and functional performance in adults with chronic stroke. Methods: This assessor-blinded, two-arm randomized controlled trial was conducted at Therapy Plus Clinic, Lahore, Pakistan. Twenty-eight adults with chronic stroke were allocated equally to mirror therapy plus task-oriented training or task-oriented training alone. Outcomes were assessed at baseline and immediately after treatment. The primary outcome was the Fugl-Meyer Assessment–Upper Extremity, and the secondary outcome was the Action Research Arm Test. Within-group changes were examined using paired-samples t tests, and change scores were compared between groups using independent-samples t tests. Results: Fugl-Meyer scores improved by 14.2 ± 5.0 points in the combined group and 7.3 ± 4.4 points in the comparison group, producing a between-group difference of 6.9 points (95% CI, 3.24–10.56; p = 0.001; Cohen’s d = 1.47). Action Research Arm Test scores improved by 14.8 ± 5.7 and 7.1 ± 4.9 points, respectively, with a between-group difference of 7.7 points (95% CI, 3.57–11.83; p = 0.001; Cohen’s d = 1.45). Conclusion: Mirror therapy combined with task-oriented training produced greater immediate improvement in upper-limb motor impairment and structured functional performance than task-oriented training alone. Keywords: chronic stroke; mirror therapy; task-oriented training; upper limb; motor recovery; Fugl-Meyer Assessment; Action Research Arm Test.

EDITORIAL INFORMATION

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INTRODUCTION

Stroke is a major cause of persistent neurological disability, and upper-limb motor impairment is among its most consequential long-term effects. Although advances in acute stroke management have improved survival, many stroke survivors continue to experience weakness, impaired selective motor control, abnormal muscle tone, sensory dysfunction, reduced coordination, and poor movement accuracy. These impairments restrict essential activities such as reaching, grasping, manipulating objects, eating, dressing, grooming, and writing, thereby reducing independence, social participation, and quality of life (1,2). Restoring functional arm and hand use is therefore a central objective of stroke rehabilitation, including among individuals who have entered the chronic stage of recovery.

Neurological recovery is most rapid during the early post-stroke period; however, the potential for motor improvement does not necessarily end when spontaneous recovery begins to plateau. Experience-dependent neuroplasticity enables the nervous system to modify the organization and efficiency of motor networks in response to structured sensory and motor experiences. Rehabilitation approaches that incorporate task specificity, repetition, intensity, progression, salience, and active participation may therefore promote motor learning and improve the effective use of residual neuromuscular capacity even during the chronic stage of stroke (3). Task-oriented training applies these principles through repeated practice of meaningful, goal-directed activities rather than isolated movements alone. Functional activities may include reaching, grasping, releasing, transporting objects, lifting a cup, folding clothing, and performing simulated feeding or grooming tasks. Evidence indicates that repetitive task training can improve functional performance after stroke, although treatment effects vary according to intervention content, practice intensity, baseline motor ability, and the outcomes assessed (4–7).

Mirror therapy is a non-invasive rehabilitation intervention that provides augmented visual feedback during movement practice. A mirror is positioned in the midsagittal plane so that the reflection of the unaffected upper limb appears to occupy the spatial location of the affected limb. Observation of this reflected movement creates the visual impression that the affected limb is moving more normally. Proposed therapeutic mechanisms include increased attention to the affected side, reinforcement of movement intention, facilitation of motor imagery, and activation of neural networks involved in action observation and motor execution (8,9). Although the precise neurophysiological mechanisms remain incompletely established, mirror-generated visual feedback may enhance the sensory and cognitive conditions under which motor practice occurs.

Randomized trials have reported improvements in upper-limb function when mirror therapy has been added to stroke rehabilitation. Yavuzer et al. found improved hand function when mirror therapy was incorporated into conventional rehabilitation for patients with subacute stroke, while Dohle et al. reported improved motor recovery among patients with severe post-stroke hemiparesis (10,11). Michielsen et al. subsequently demonstrated short-term motor improvement after mirror therapy in individuals with chronic stroke, suggesting that responsiveness to augmented visual feedback may persist beyond the period of early spontaneous recovery (12). The therapeutic relevance of mirror therapy may also depend on the activities performed during treatment. Task-based mirror therapy integrates purposeful reaching, grasping, object manipulation, and functional hand use rather than relying exclusively on simple joint movements. Arya et al. reported that this task-based approach enhanced motor recovery in people with post-stroke hemiparesis (13).

Systematic reviews generally support a potential benefit of mirror therapy for upper-limb motor recovery after stroke but identify considerable heterogeneity in stroke chronicity, baseline impairment, treatment content, intervention dosage, comparator design, and outcome selection (14–16). In several previous studies, mirror therapy was compared with usual care or with interventions that did not provide equivalent functional practice, making it difficult to separate the specific contribution of mirror-generated visual feedback from the effect of additional rehabilitation exposure. A direct comparison between mirror therapy combined with task-oriented training and task-oriented training alone is therefore clinically relevant because both groups undertake purposeful upper-limb practice while the principal difference is the addition of mirror visual feedback.

The objective of this randomized controlled trial was to determine whether adding mirror therapy to task-oriented training produced greater short-term improvement in upper-limb motor function and functional performance than task-oriented training alone in adults with chronic stroke. The primary hypothesis was that participants receiving mirror therapy combined with task-oriented training would demonstrate greater improvement in Fugl-Meyer Assessment–Upper Extremity scores from baseline to the immediate post-treatment assessment. The secondary hypothesis was that the combined intervention would produce greater improvement in Action Research Arm Test scores over the same period.

MATERIALS AND METHODS

A two-arm, parallel-group, assessor-blinded randomized controlled trial was conducted at Therapy Plus Clinic, Architect Society, Lahore, Pakistan. The trial compared mirror therapy combined with task-oriented training with task-oriented training alone for improving upper-limb motor function and functional performance in adults with chronic stroke. An active-comparator design was used to evaluate the additional contribution of mirror-generated visual feedback while both groups participated in purposeful upper-limb task practice. The study was designed and reported in accordance with the CONSORT recommendations for parallel-group randomized trials (17).

Adults with a medically confirmed ischemic or hemorrhagic stroke occurring at least six months before enrolment were screened for eligibility. Participants were included if they had unilateral upper-limb motor impairment, were medically stable, could maintain an appropriate sitting position during treatment, and were able to understand and follow simple instructions. Individuals were excluded if they had experienced a recurrent stroke, had bilateral impairment, severe cognitive or communication difficulties, severe visual impairment, fixed upper-limb contracture, severe pain or spasticity preventing safe movement, another neurological disorder, a major musculoskeletal condition affecting the upper limb, or an unstable medical condition. Individuals participating in another structured upper-limb rehabilitation programme during the study were also excluded.

Eligible participants received verbal and written information about the study, and written informed consent was obtained before enrolment. Twenty-eight participants were enrolled and randomly allocated in a 1:1 ratio to mirror therapy combined with task-oriented training or task-oriented training alone. The allocation sequence was computer generated, and assignments were concealed using sequentially numbered, opaque, sealed envelopes that were opened only after completion of the baseline assessment. Participants and treating therapists could not be blinded because of the nature of the interventions. Outcome assessments were therefore performed by an assessor who remained unaware of treatment allocation, and participants were instructed not to disclose their intervention during assessment.

Participants allocated to the combined-intervention group performed task-oriented upper-limb activities while receiving mirror-generated visual feedback. A mirror was positioned in the midsagittal plane so that the reflection of the unaffected upper limb visually corresponded to the position of the affected limb. Functional practice included reaching, object transfer, grasping, releasing, folding, and simulated feeding and grooming activities. Participants allocated to the comparison group performed task-oriented practice involving corresponding functional upper-limb activities without mirror-generated visual feedback. Standardized intervention procedures and consistent progression criteria were applied, and comparable therapist contact and rehabilitation exposure were maintained between groups. Participants were instructed to avoid additional structured upper-limb therapy during the study to reduce treatment contamination.

The primary outcome was upper-limb motor impairment measured using the Fugl-Meyer Assessment–Upper Extremity. The instrument evaluates reflex activity, voluntary movement, wrist and hand control, coordination, and movement speed. Scores range from 0 to 66, with higher scores indicating better upper-limb motor function (18,19). The secondary outcome was functional upper-limb performance measured using the Action Research Arm Test. The test evaluates grasp, grip, pinch, and gross arm movement, with scores ranging from 0 to 57; higher scores indicate better functional performance (20,21). Outcomes were assessed at baseline and immediately after completion of treatment by the same blinded assessor using standardized assessment procedures.

Baseline information included age, sex, stroke type, affected side, involvement of the dominant side, duration since stroke, medical history, and previous rehabilitation. Treatment attendance, missed sessions, protocol deviations, and adverse events were documented during the trial. Random sequence generation and allocation concealment were used to reduce selection bias, while assessor blinding was used to reduce detection bias. Standardized intervention procedures, consistent progression criteria, comparable therapist contact, and restriction of additional upper-limb rehabilitation were used to reduce performance bias and between-group contamination.

Data were analysed using IBM SPSS Statistics version 26.0. Continuous variables were summarized as mean ± standard deviation, and categorical variables were presented as frequency and percentage. Baseline continuous variables were compared descriptively using Welch's independent-samples t test, while categorical variables were compared using Fisher's exact test because of the small group sizes. The primary treatment effect was evaluated by comparing the change in Fugl-Meyer Assessment–Upper Extremity scores from baseline to post-treatment between groups using an independent-samples t test. The same approach was used for the Action Research Arm Test. Between-group effects were expressed as mean differences with 95% confidence intervals and Cohen's d standardized effect sizes calculated using the pooled standard deviation of the change scores. Within-group changes were evaluated using paired-samples t tests and were reported as mean changes with 95% confidence intervals. All randomized participants were analysed in their assigned groups. Because post-treatment outcome data were available for all participants, no missing-value imputation was required. Statistical tests were two sided, and statistical significance was set at $p < 0.05$.

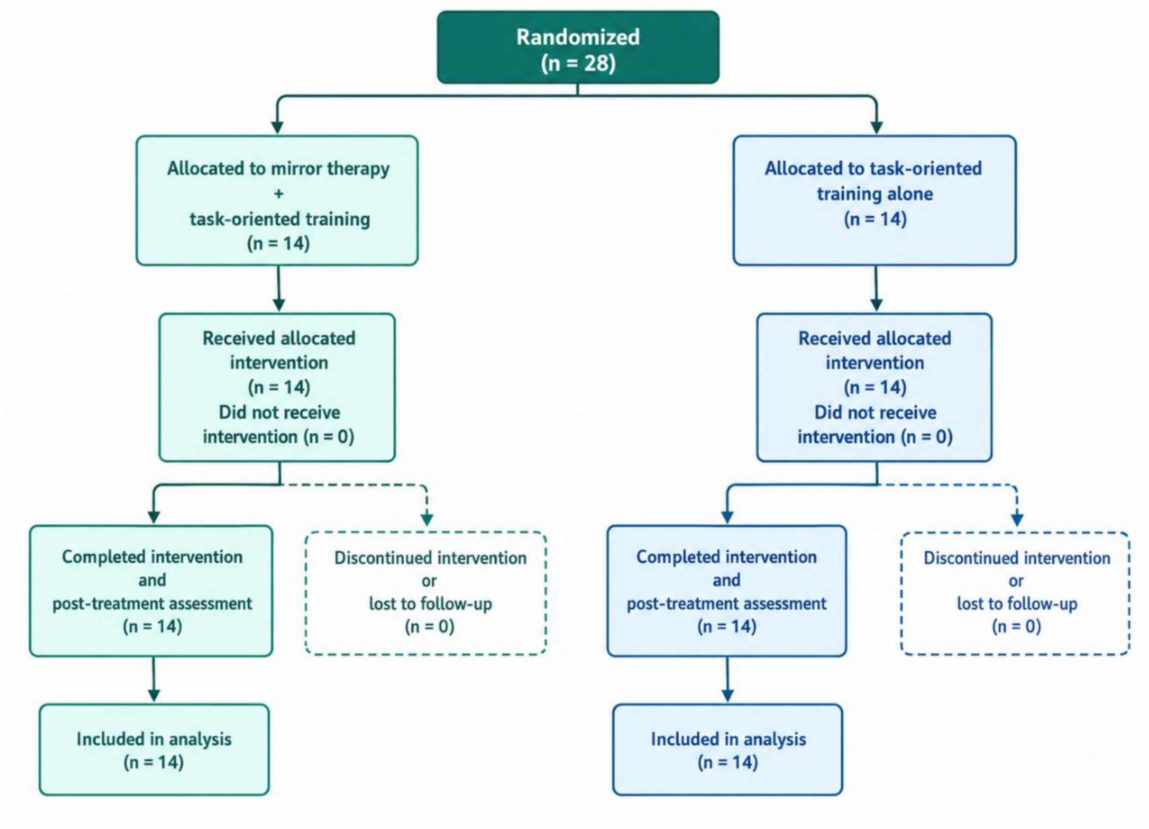

Figure 1 CONSORT flow diagram of participant allocation, follow-up, and analysis. Twenty-eight adults with chronic stroke were randomized equally to mirror therapy combined with task-oriented training or task-oriented training alone. All participants received the allocated intervention, completed the immediate post-treatment assessment, and were included in the analysis.

Ethical approval was obtained before participant recruitment. Participation was voluntary, written informed consent was obtained from all participants, and confidentiality was maintained by assigning study identification codes and storing personal information separately from the analytical dataset.

RESULTS

Twenty-eight participants were randomized, with 14 assigned to mirror therapy combined with task-oriented training and 14 assigned to task-oriented training alone. All randomized participants completed the intervention and immediate post-treatment assessment; therefore, outcome data were available for the full randomized sample.

Baseline demographic and clinical characteristics are presented in Table 1. Mean age was 58.4 ± 8.1 years in the combined-intervention group and 59.1 ± 7.6 years in the task-oriented-training group. Men represented 64.3% and 57.1% of the groups, respectively. Ischemic stroke was the predominant stroke type in both groups, accounting for 78.6% of participants in the combined-intervention group and 71.4% in the comparison group. Mean duration since stroke was 18.6 ± 7.4 months and 19.2 ± 8.0 months, respectively. Baseline FMA-UE and ARAT scores were also descriptively similar. Exploratory baseline comparisons did not identify large numerical differences between groups; p-values ranged from 0.815 to 0.871 for continuous variables and were 1.000 for the categorical comparisons.

Table 1. Baseline Demographic and Clinical Characteristics

Variable	Mirror therapy + task-oriented training (n = 14)	Task-oriented training (n = 14)	p-value
Age, years, mean ± SD	58.4 ± 8.1	59.1 ± 7.6	0.815
Sex, n (%)			1.000
Male	9 (64.3)	8 (57.1)	
Female	5 (35.7)	6 (42.9)	
Stroke type, n (%)			1.000
Ischemic	11 (78.6)	10 (71.4)	
Hemorrhagic	3 (21.4)	4 (28.6)	
Affected side, n (%)			1.000
Right	8 (57.1)	7 (50.0)	
Left	6 (42.9)	7 (50.0)	
Duration since stroke, months, mean ± SD	18.6 ± 7.4	19.2 ± 8.0	0.838
Dominant side affected, n (%)	7 (50.0)	6 (42.9)	1.000
FMA-UE score, mean ± SD	31.6 ± 8.2	32.1 ± 7.9	0.871
ARAT score, mean ± SD	23.8 ± 9.5	24.4 ± 9.1	0.866

Upper-limb outcome changes are presented in Table 2. FMA-UE scores increased from 31.6 ± 8.2 to 45.8 ± 8.6 in the combined-intervention group, representing a mean improvement of 14.2 ± 5.0 points (95% CI, 11.31 to 17.09; p < 0.001). In the task-oriented-training group, FMA-UE scores increased from 32.1 ± 7.9 to 39.4 ± 8.1, corresponding to a mean improvement of 7.3 ± 4.4 points (95% CI, 4.76 to 9.84; p < 0.001).

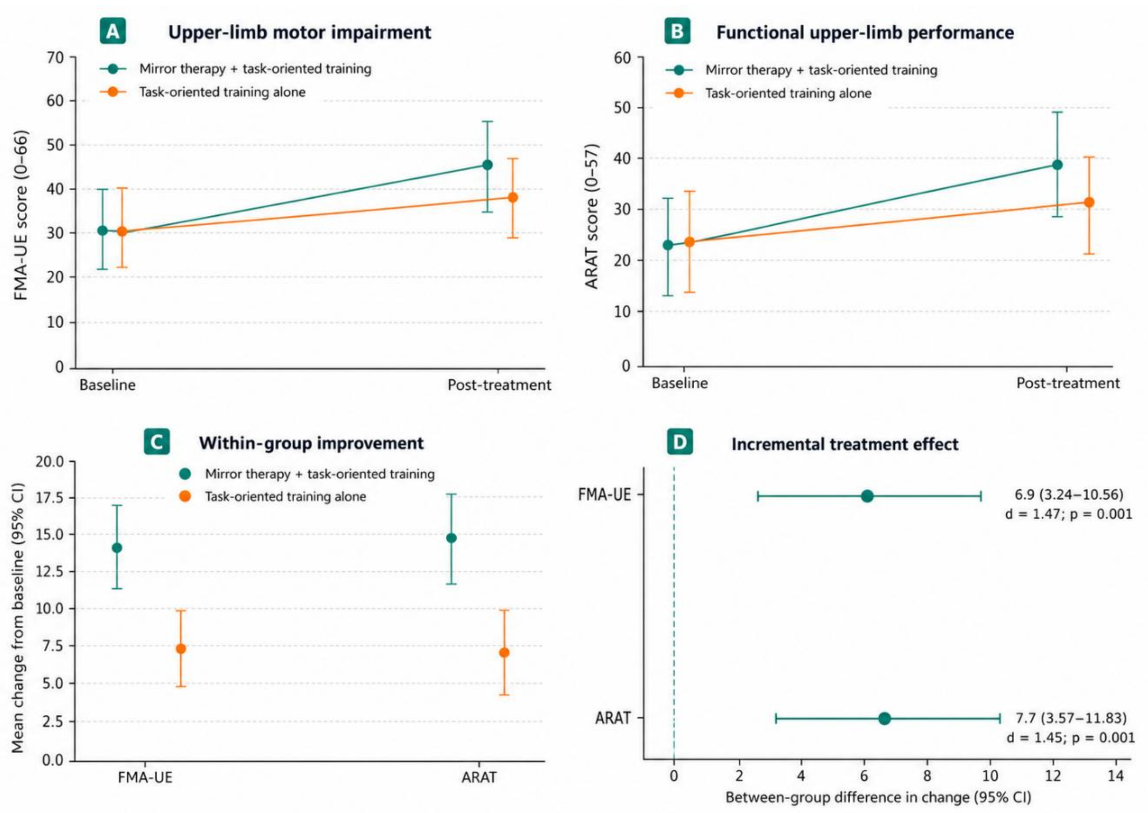

Figure 2 Immediate upper-limb outcomes following mirror therapy combined with task-oriented training compared with task-oriented training alone in adults with chronic stroke. Panels A and B present baseline and immediate post-treatment mean scores with standard-deviation error bars for the Fugl-Meyer Assessment–Upper Extremity and Action Research Arm Test, respectively. Panel C presents mean within-group improvements with 95% confidence intervals. Panel D presents the incremental treatment effects

calculated as the change in the combined-intervention group minus the change in the task-oriented-training group. FMA-UE scores improved by 14.2 points in the combined-intervention group and 7.3 points in the comparison group, producing a between-group difference of 6.9 points (95% CI, 3.24–10.56; p = 0.001; Cohen's d = 1.47). ARAT scores improved by 14.8 and 7.1 points, respectively, with a between-group difference of 7.7 points (95% CI, 3.57–11.83; p = 0.001; Cohen's d = 1.45). Error bars in Panels A and B represent standard deviations; error bars in Panels C and D represent 95% confidence intervals. ARAT, Action Research Arm Test; CI, confidence interval; FMA-UE, Fugl-Meyer Assessment–Upper Extremity.

The improvement was 6.9 points greater in the combined-intervention group than in the comparison group (95% CI, 3.24 to 10.56; p = 0.001). The standardized between-group effect was large (Cohen's d = 1.47).

Table 2. Within-Group Changes and Between-Group Treatment Effects

Outcome	Combined Baseline	Combined Post	Change\(95% CI)	Within-group p	Control Baseline	Control Post	Control Change (95% CI)	Within-group p	Group Difference (95% CI)	Between-group p	Cohen's d
FMA-UE	31.6 ± 8.2	45.8 ± 8.6	14.2 ± 5.0 (11.31–17.09)	<0.001	32.1 ± 7.9	39.4 ± 8.1	7.3 ± 4.4 (4.76–9.84)	<0.001	6.9 (3.24–10.56)	0.001	1.47
ARAT	23.8 ± 9.5	38.6 ± 10.2	14.8 ± 5.7 (11.51–18.09)	<0.001	24.4 ± 9.1	31.5 ± 9.4	7.1 ± 4.9 (4.27–9.93)	<0.001	7.7 (3.57–11.83)	0.001	1.45

ARAT scores increased from 23.8 ± 9.5 to 38.6 ± 10.2 in the combined-intervention group, producing a mean improvement of 14.8 ± 5.7 points (95% CI, 11.51 to 18.09; p < 0.001). Scores in the task-oriented-training group increased from 24.4 ± 9.1 to 31.5 ± 9.4, representing a mean improvement of 7.1 ± 4.9 points (95% CI, 4.27 to 9.93; p < 0.001). The between-group difference in ARAT change was 7.7 points in favour of the combined intervention (95% CI, 3.57 to 11.83; p = 0.001), with a large standardized effect (Cohen's d = 1.45). The concordant findings for FMA-UE and ARAT indicate that the addition of mirror-generated visual feedback was associated with greater immediate improvement in both upper-limb motor impairment and performance of structured functional tasks than task-oriented training alone.

DISCUSSION

This randomized controlled trial found that adding mirror therapy to task-oriented training produced greater immediate improvement in upper-limb motor impairment and functional performance than task-oriented training alone in adults with chronic stroke. Both groups improved after treatment, indicating that structured task-oriented practice was beneficial; however, the combined-intervention group demonstrated consistently greater gains across the Fugl-Meyer Assessment–Upper Extremity and Action Research Arm Test. The agreement between these impairment-level and activity-level outcomes suggests that the observed treatment effect was not restricted to isolated motor control but extended to performance of structured functional upper-limb tasks.

The improvement observed in both groups is consistent with the principles underlying task-oriented rehabilitation. Repetitive practice of meaningful, goal-directed activities may facilitate motor learning by promoting task specificity, active engagement, movement problem-solving, and repeated use of the affected upper limb (3–5). Previous evidence indicates that repetitive task training can improve functional ability after stroke, although the magnitude of improvement varies according to treatment intensity, task content, baseline motor capacity, and the outcomes assessed (6,7). The present findings therefore support task-oriented practice as an important component of chronic stroke rehabilitation while suggesting that augmented visual feedback may increase the magnitude of short-term improvement.

The additional benefit associated with mirror therapy is broadly consistent with previous randomized trials. Yavuzer et al. reported improved hand function when mirror therapy was added to conventional rehabilitation in patients with subacute stroke, while Dohle et al. found that mirror therapy promoted motor recovery among individuals with severe post-stroke hemiparesis (10,11). Although these studies included participants at earlier stages of stroke recovery, Michielsen et al. demonstrated short-term motor improvement following mirror therapy in individuals with chronic stroke (12). The present results extend this evidence by showing an advantage when mirror-generated visual feedback was incorporated into functional task practice and compared directly with task-oriented training alone.

The observed improvement in Action Research Arm Test performance is clinically relevant because the instrument evaluates grasping, gripping, pinching, gross arm movement, and object manipulation rather than isolated joint movement alone (20,21). Arya et al. similarly reported that task-based mirror therapy enhanced motor recovery in people with post-stroke hemiparesis, supporting the use of purposeful objectoriented activities during mirror-mediated practice (13). In the present trial, the direction and magnitude of improvement were similar across FMA-UE and ARAT outcomes. This concordance suggests that improvements in voluntary movement control may have been accompanied by an increased capacity to apply that control during standardized functional activities.

Several mechanisms may explain the additional improvement associated with mirror therapy. Observation of the reflected unaffected limb may increase attention toward the affected side, strengthen movement intention, support motor imagery, and engage cortical networks involved in action observation and motor execution (8,9). Mirror feedback may also provide a more coherent visual representation of successful movement, potentially reducing the mismatch between intended and perceived movement. When this feedback is combined with purposeful task practice, it may reinforce sensorimotor associations and increase participant engagement. These explanations remain biologically plausible rather than definitively established, and the present clinical data cannot identify which mechanism was primarily responsible for the observed effect.

The direction of the findings is also consistent with systematic reviews reporting potential benefits of mirror therapy for upper-limb recovery after stroke (14–16). These reviews have nevertheless emphasized substantial heterogeneity in participant characteristics, stroke chronicity, intervention content, treatment dosage, comparator selection, and follow-up duration. The use of task-oriented training as an active comparator in the present trial strengthens the clinical relevance of the comparison because participants in both groups undertook purposeful upper-limb practice. However, incomplete reporting of intervention frequency, session duration, treatment intensity, adherence, and fidelity prevents firm determination of whether rehabilitation exposure was fully comparable between groups. The specific contribution of mirror-generated feedback should therefore be interpreted cautiously.

The large standardized effects observed for both outcomes indicate substantial separation between the mean change scores of the groups. Nevertheless, standardized effect sizes do not by themselves establish that every participant experienced a perceptible or clinically meaningful benefit. Interpretation should primarily consider the original-scale between-group differences and their confidence intervals. The study did not report prespecified responder thresholds or the proportion of participants achieving clinically important improvement, and it did not assess whether the gains translated into spontaneous use of the affected arm in home and community settings.

The study had several strengths. Random allocation and concealed assignment reduced the risk of selection bias, while assessor blinding reduced detection bias. The use of an active comparator allowed both groups to receive purposeful rehabilitation rather than comparing the combined intervention with no treatment. Complete immediate post-treatment data were available for all randomized participants, and the direction of the findings was consistent across two established upper-limb measures assessing related but distinct domains.

The findings should also be interpreted in light of important limitations. The sample was small and recruited from a single rehabilitation centre, limiting statistical precision and generalizability. Participants and treating therapists could not be blinded, creating the possibility that expectations, motivation, therapist behaviour, or differential encouragement influenced treatment performance. Outcomes were assessed only immediately after treatment, so the durability of the observed improvements remains unknown. The study did not evaluate spontaneous arm use, patient-reported function, quality of life, participation, treatment acceptability, or resource requirements.

Additional limitations concern analysis and reporting. The principal comparisons were based on unadjusted change scores rather than baseline-adjusted models, and the small sample may not have balanced all measured and unmeasured prognostic characteristics. No prospective sample-size calculation was reported, and the absence of detailed treatment-dose, adherence, protocol-fidelity, and adverse-event results limits assessment of reproducibility, feasibility, and safety. The success of assessor blinding was not formally evaluated, and the available manuscript does not provide sufficient information about trial registration or the complete participant-screening process.

Overall, the findings provide preliminary evidence that mirror therapy may enhance the short-term effects of task-oriented upper-limb training in adults with chronic stroke. The consistency of the FMA-UE and ARAT results supports the potential value of combining augmented visual feedback with purposeful functional practice. However, the magnitude and durability of the benefit require confirmation in adequately powered multicentre trials with prospectively registered protocols, complete intervention reporting, treatment-fidelity monitoring, baseline-adjusted analyses, clinically meaningful responder outcomes, and longer-term assessment.

CONCLUSION

In this small, single-centre randomized controlled trial, mirror therapy combined with task-oriented training produced greater immediate improvement in upper-limb motor impairment and structured functional performance than task-oriented training alone in adults with chronic stroke. The findings support the potential short-term value of incorporating mirror-generated visual feedback into task-oriented upper-limb rehabilitation, but the magnitude, clinical relevance, durability, and generalizability of the observed effects remain to be confirmed.

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