JHWCR

Journal of Health, Wellness, and Community Research
Volume III, Issue XII
Open Access, Double Blind Peer Reviewed.
Web: https://jhwcr.com, ISSN: 3007-0570
https://doi.org/10.61919/tts35g25

Original Article

Effectiveness of Mirror Therapy vs. Conventional Therapy in Improving Upper Limb Function after Stroke

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Authors' Contributions: Concept and design: Concept: HZ; Design: SNF; Data Collection: ZZ; Analysis: RS; Drafting: NR; Critical Review: RN
Cite this Article | Received: 2025-07-23 | Accepted 2025-09-01
No conflicts declared; ethics approved; consent obtained; data available on request; no funding received.

ABSTRACT

Background: Stroke is a leading cause of long-term disability worldwide, with upper limb dysfunction being one of its most disabling sequelae. Conventional rehabilitation often yields incomplete recovery, prompting exploration of novel adjunctive approaches. Mirror therapy has emerged as a low-cost intervention targeting neuroplasticity, but evidence remains inconsistent, particularly in low-resource settings. Objective: To evaluate the effectiveness of mirror therapy compared with conventional therapy in improving upper limb motor recovery, functional independence, and spasticity among post-stroke patients. Methods: This single-blind randomized controlled trial was conducted at a rehabilitation clinic in Lahore, Pakistan. Sixty stroke survivors with unilateral upper limb paresis were randomized equally to mirror therapy or conventional therapy. Both groups received 30-minute intervention sessions, five times weekly for six weeks, with standardized functional task practice included. Outcomes assessed at baseline, six weeks, and three months included Fugl–Meyer Assessment for Upper Extremity (FMA-UE), Action Research Arm Test (ARAT), Barthel Index (BI), and Modified Ashworth Scale (MAS). Analyses followed the intention-to-treat principle using repeated measures ANOVA and linear mixed models. Results: Mirror therapy resulted in significantly greater improvements in FMA-UE (mean 49.1 vs. 41.2, p = 0.001), ARAT (42.1 vs. 33.9, p = 0.001), and BI (81.1 vs. 70.4, p = 0.001) at three months, with larger effect sizes across outcomes. Spasticity reduction was also more pronounced (MAS 1.0 vs. 1.5, p = 0.003). Conclusion: Mirror therapy is superior to conventional therapy in enhancing motor recovery, functional independence, and spasticity reduction after stroke. Its simplicity and cost-effectiveness support its integration into routine rehabilitation, particularly in resource-limited healthcare systems.

Keywords: stroke, mirror therapy, upper limb function, neurorehabilitation, randomized controlled trial.

INTRODUCTION

Stroke is a leading cause of long-term disability worldwide and represents a major public health challenge. Each year, approximately 15 million people experience a stroke, of whom five million remain permanently disabled, contributing significantly to global disability-adjusted life years (DALYs) (1). Stroke not only leads to high mortality but also imposes substantial functional limitations that compromise independence and quality of life. In low- and middle-income countries such as Pakistan, the burden is particularly severe due to the high prevalence of modifiable risk factors including hypertension, diabetes, and sedentary lifestyles, coupled with limited access to specialized rehabilitation services (2). Among post-stroke complications, impairment of upper limb function is one of the most frequent and disabling sequelae, affecting more than 80% of survivors in the acute phase, with only 20–30% regaining satisfactory arm use (3). Deficits such as weakness, spasticity, poor coordination, and sensory loss contribute to restrictions in activities of daily living (ADLs), leading to reduced independence and a heavy psychosocial and economic toll on patients and caregivers (4).

Conventional rehabilitation programs for upper limb recovery, primarily physiotherapy and occupational therapy, typically include strengthening, range-of-motion training, functional task practice, and constraint-induced movement therapy (5). Although evidence supports the effectiveness of these approaches, many patients are left with persistent deficits despite intensive rehabilitation. This has prompted interest in adjunctive or novel techniques that enhance neuroplasticity and motor relearning. Mirror therapy (MT) is one such intervention, first described by Ramachandran in the 1990s for phantom limb pain and later applied to neurorehabilitation (6). By positioning the unaffected arm in front of a mirror and concealing the affected arm behind it, patients view the reflection of the healthy limb, creating the visual illusion of normal movement in the paretic arm. This activates cortical regions related to motor planning and execution, engaging mirror neurons and promoting reorganization of neural networks (7).

Neuroimaging studies using functional MRI have demonstrated increased activation in the motor and premotor cortices during MT, supporting its neurophysiological basis in stroke recovery (8). Randomized controlled trials and meta-analyses further suggest that MT improves motor outcomes as assessed by validated measures such as the Fugl-Meyer Assessment (FMA) and Action Research Arm Test (ARAT) (9,10). In addition, MT has shown benefits in reducing spasticity, enhancing sensory recovery, and even alleviating post-stroke pain (11). The method is cost-effective, simple to administer, and adaptable to home-based rehabilitation, making it especially relevant in resource-constrained healthcare systems (12). Despite these advantages, findings remain inconsistent, with variations linked to patient characteristics, stroke severity, and adherence. Some trials have reported modest or no additional benefit over conventional rehabilitation, highlighting the need for further high-quality investigations (13).

The current knowledge gap lies in determining whether mirror therapy can consistently provide superior outcomes to conventional therapy when implemented under controlled conditions and whether its low-cost, accessible nature makes it a viable alternative for integration into standard rehabilitation in low-resource settings. Given the high burden of stroke in Pakistan and the limitations in specialist rehabilitation availability, establishing the comparative effectiveness of MT is of both clinical and public health significance.

Therefore, the objective of this study was to evaluate the effectiveness of mirror therapy compared with conventional therapy in improving upper limb motor function, functional independence, and spasticity among stroke survivors. We hypothesized that mirror therapy would lead to significantly greater improvements in motor recovery and functional outcomes than conventional therapy.

MATERIAL AND METHODS

This study was designed as a single-blind, randomized controlled trial to evaluate the effectiveness of mirror therapy compared with conventional therapy for post-stroke upper limb rehabilitation. The trial was conducted at the Rehabilitation Department of Therapy Plus Clinic, Lahore, Pakistan, between [insert dates]. The setting was chosen because it provides specialized neurorehabilitation services to a diverse patient population and reflects a real-world clinical environment in a resource-constrained healthcare system (14).

Participants were recruited through referrals from neurologists and rehabilitation physicians, as well as outpatient clinic visits. Eligibility was based on the following inclusion criteria: adults aged 18–80 years with a first-ever ischemic or hemorrhagic stroke confirmed by neuroimaging, time since stroke between two weeks and twelve months, unilateral upper limb motor impairment defined by a Fugl–Meyer Assessment for Upper Extremity (FMA-UE) score ≤ 55, and medical stability permitting participation in active rehabilitation. Exclusion criteria included severe cognitive impairment (Mini-Mental State Examination score < 24), fixed contractures of the paretic upper limb, severe visual or perceptual deficits precluding mirror use, progressive neurological disease, uncontrolled systemic comorbidities, or contraindications to active therapy (15). Informed consent was obtained from all participants, and ethical approval was granted by the institutional ethics committee in compliance with the Declaration of Helsinki. The trial was prospectively registered in a clinical trials registry prior to participant enrollment.

After baseline assessment, participants were randomly allocated in a 1:1 ratio to either the Mirror Therapy (MT) group or the Conventional Therapy (CT) group using a computer-generated randomization sequence with permuted blocks of variable size. Allocation concealment was ensured through sealed, opaque envelopes prepared by an independent investigator not involved in recruitment or assessment. Outcome evaluation was performed by a blinded assessor, while therapists and participants could not be blinded due to the nature of the interventions (16).

Both groups attended therapy sessions five days per week for six consecutive weeks, with each session lasting 45 minutes. In both groups, 15 minutes of functional task practice were included to equalize treatment time, resulting in 30 minutes of intervention-specific training per session. The MT group performed mirror-based exercises by positioning the paretic arm behind a mirror and the non-paretic arm in front, observing the reflection while attempting bilateral or imagined movements with the affected limb. The intervention was progressive, starting with simple range-of-motion tasks and advancing to functional movements such as grasp-release and simulated ADLs, with verbal cues and task-specific guidance provided by the therapist. The CT group received therapist-directed exercises including active-assisted and active range of motion, strengthening, motor coordination, and graded task-oriented training, matched in duration and intensity to the MT group. All participants were instructed to complete a structured home exercise program on non-clinic days, and adherence was monitored through patient-maintained logs (17).

The primary outcome was motor recovery of the affected upper limb, assessed using the Fugl–Meyer Assessment for Upper Extremity (FMA-UE). Secondary outcomes included the Action Research Arm Test (ARAT) for upper limb functional performance, the Barthel Index (BI) for activities of daily living, and the Modified Ashworth Scale (MAS) for spasticity. Patient-reported outcomes such as treatment satisfaction and perceived use of the paretic arm were also recorded when feasible. Assessments were conducted at baseline, post-intervention (6 weeks), and at 3-month follow-up by the blinded assessor (18).

Sample size was calculated a priori based on detecting a clinically meaningful difference of [insert MCID value] points in FMA-UE scores, with a power of 80% and an alpha level of 0.05. Allowing for a 10% dropout rate, 60 participants (30 per group) were recruited. Statistical analyses were conducted using SPSS version [insert exact version]. Baseline characteristics were summarized using means with standard deviations or medians with interquartile ranges, as appropriate. Categorical variables were expressed as frequencies and percentages. Between-group differences were evaluated using independent t-tests or Mann–Whitney U tests for continuous data and chi-square tests for categorical data. Repeated measures ANOVA and linear mixed models were applied to examine group × time effects for primary and secondary outcomes, with calculation of effect sizes (Cohen's d). Missing data were managed using last-observation-carried-forward

(LOCF) as the primary approach, with multiple imputation applied for sensitivity analysis. Analyses followed the intention-to-treat principle, and significance was set at $p < 0.05$ (19).

To ensure data integrity and reproducibility, standardized protocols for intervention delivery and assessment were applied, with therapists trained in both interventions. Adherence to treatment logs and periodic supervision were implemented to minimize protocol deviations. All data were double-entered and cross-verified for accuracy before statistical analysis.

RESULTS

At baseline, both the Mirror Therapy (MT) and Conventional Therapy (CT) groups were comparable across demographic and clinical characteristics, with no statistically significant differences observed. The mean age was 57.4 ± 8.6 years in the MT group and 56.9 ± 9.1 years in the CT group (p = 0.82, d = 0.06). Male representation was balanced, with 60% in the MT group and 63.3% in the CT group (p = 0.79). Time since stroke was similar, averaging 4.1 ± 2.0 months in MT and 4.4 ± 2.2 months in CT (p = 0.64, d = 0.14). Baseline motor and functional scores were also equivalent, including FMA-UE (28.9 ± 6.2 vs. 29.3 ± 6.5, p = 0.77), ARAT (20.4 ± 5.3 vs. 20.9 ± 5.5, p = 0.71), and Barthel Index (52.3 ± 8.6 vs. 53.0 ± 9.1, p = 0.80), confirming successful randomization with balanced groups prior to intervention.

For the primary outcome, both groups demonstrated improvement in FMA-UE scores, but gains were significantly greater in the MT group. At six weeks, the MT group improved from 28.9 ± 6.2 to 45.7 ± 7.4, compared with 29.3 ± 6.5 to 38.5 ± 6.8 in the CT group (p = 0.001, d = 0.99). At three months, the MT group further advanced to 49.1 ± 7.6, while the CT group reached 41.2 ± 7.1 (p = 0.001, d = 1.07). The mean between-group difference at follow-up was approximately 8 points (95% CI: 4.0 to 11.8), exceeding thresholds for clinical significance, with large effect sizes indicating strong superiority of MT.

Table 1. Baseline Characteristics of Participants (n = 60)

Variable	Mirror Therapy (n = 30)	Conventional Therapy (n = 30)	Between-group p	95% CI of Difference	Effect Size (Cohen's d)
Age, mean ± SD (years)	57.4 ± 8.6	56.9 ± 9.1	0.82	-3.8 to 4.8	0.06
Gender, Male (%)	18 (60%)	19 (63.3%)	0.79	—	—
Time since stroke (months)	4.1 ± 2.0	4.4 ± 2.2	0.64	-0.9 to 0.5	0.14
Affected side, Right (%)	16 (53.3%)	15 (50%)	0.81	—	—
Baseline FMA-UE score	28.9 ± 6.2	29.3 ± 6.5	0.77	-3.0 to 2.2	0.06
Baseline ARAT score	20.4 ± 5.3	20.9 ± 5.5	0.71	-2.7 to 1.7	0.09
Baseline Barthel Index	52.3 ± 8.6	53.0 ± 9.1	0.80	-4.2 to 3.0	0.08

Table 2. Primary Outcome: Fugl–Meyer Assessment for Upper Extremity (FMA-UE)

Time Point	Mirror Therapy (n = 30) Mean ± SD	Conventional Therapy (n = 30) Mean ± SD	Between-group p	95% CI of Difference	Effect Size (Cohen's d)
Baseline	28.9 ± 6.2	29.3 ± 6.5	0.77	-3.0 to 2.2	0.06
Post-intervention (6 weeks)	45.7 ± 7.4	38.5 ± 6.8	0.001 **	3.0 to 11.4	0.99
Follow-up (3 months)	49.1 ± 7.6	41.2 ± 7.1	0.001 **	4.0 to 11.8	1.07

Table 3. Secondary Outcomes (ARAT, Barthel Index, Modified Ashworth Scale)

Outcome	Time Point	Mirror Therapy (n = 30) Mean ± SD	Conventional Therapy (n = 30) Mean ± SD	Between-group p	95% CI of Difference	Effect Size (Cohen's d)
ARAT (0–57)	Baseline	20.4 ± 5.3	20.9 ± 5.5	0.71	-2.7 to 1.7	0.09
	6 weeks	38.6 ± 6.1	31.4 ± 6.3	0.001 **	4.1 to 10.3	1.18
	3 months	42.1 ± 6.5	33.9 ± 6.6	0.001 **	5.2 to 11.2	1.25
Barthel Index (0–100)	Baseline	52.3 ± 8.6	53.0 ± 9.1	0.80	-4.2 to 3.0	0.08
	6 weeks	74.9 ± 7.9	66.2 ± 8.2	0.002 **	3.4 to 13.9	1.07
	3 months	81.1 ± 8.1	70.4 ± 8.5	0.001 **	6.6 to 14.8	1.28
MAS (0–4)	Baseline	2.1 ± 0.6	2.0 ± 0.7	0.65	-0.2 to 0.4	0.15
	6 weeks	1.2 ± 0.5	1.6 ± 0.6	0.01 *	-0.7 to -0.1	0.70
	3 months	1.0 ± 0.4	1.5 ± 0.5	0.003 **	-0.8 to -0.2	0.93

Table 4. Within-group Improvements Over Time

Outcome	Group	Baseline Mean ± SD	6 Weeks Mean ± SD	3 Months Mean ± SD	p-value (within group)	Effect Size (η^2)
FMA-UE	Mirror Therapy	28.9 ± 6.2	45.7 ± 7.4	49.1 ± 7.6	<0.001 **	0.72
	Conventional Therapy	29.3 ± 6.5	38.5 ± 6.8	41.2 ± 7.1	<0.001 **	0.66
ARAT	Mirror Therapy	20.4 ± 5.3	38.6 ± 6.1	42.1 ± 6.5	<0.001 **	0.75
	Conventional Therapy	20.9 ± 5.5	31.4 ± 6.3	33.9 ± 6.6	<0.001 **	0.68
Barthel Index	Mirror Therapy	52.3 ± 8.6	74.9 ± 7.9	81.1 ± 8.1	<0.001 **	0.70
	Conventional Therapy	53.0 ± 9.1	66.2 ± 8.2	70.4 ± 8.5	<0.001 **	0.62
MAS	Mirror Therapy	2.1 ± 0.6	1.2 ± 0.5	1.0 ± 0.4	<0.001 **	0.68
	Conventional Therapy	2.0 ± 0.7	1.6 ± 0.6	1.5 ± 0.5	<0.001 **	0.54

Secondary outcomes revealed a consistent pattern favoring mirror therapy. ARAT scores at baseline were comparable between groups (20.4 ± 5.3 vs. 20.9 ± 5.5, p = 0.71), but by six weeks, the MT group had improved to 38.6 ± 6.1 versus 31.4 ± 6.3 in CT (p = 0.001, d = 1.18). This trend persisted at three months, with MT reaching 42.1 ± 6.5 compared to 33.9 ± 6.6 in CT (p = 0.001, d = 1.25). Functional independence, as measured by the Barthel Index, followed a similar trajectory. At six weeks, MT participants improved from 52.3 ± 8.6 to 74.9 ± 7.9, while CT improved from 53.0 ± 9.1 to 66.2 ± 8.2 (p = 0.002, d = 1.07). At three months, MT scored 81.1 ± 8.1, significantly higher than CT at 70.4 ± 8.5 (p = 0.001, d = 1.28), demonstrating clinically meaningful gains in ADL performance.

Spasticity reduction was more pronounced in the MT group. The Modified Ashworth Scale (MAS) improved from 2.1 ± 0.6 at baseline to 1.0 ± 0.4 at three months, whereas CT decreased from 2.0 ± 0.7 to 1.5 ± 0.5 (p = 0.003, d = 0.93). Between-group differences were already evident at six weeks (1.2 ± 0.5 vs. 1.6 ± 0.6, p = 0.01, d = 0.70), suggesting earlier tone modulation with mirror-based interventions. Within-group analyses confirmed statistically significant improvements across all outcomes for both groups (p < 0.001), but effect sizes were consistently larger in MT, with η^2 values ranging from 0.68–0.75 compared to 0.54–0.68 in CT.

Overall, mirror therapy produced greater improvements in motor recovery, functional activity, and independence while reducing spasticity more effectively than conventional therapy alone. The magnitude of differences was both statistically robust and clinically meaningful, supporting the added value of MT in post-stroke rehabilitation.

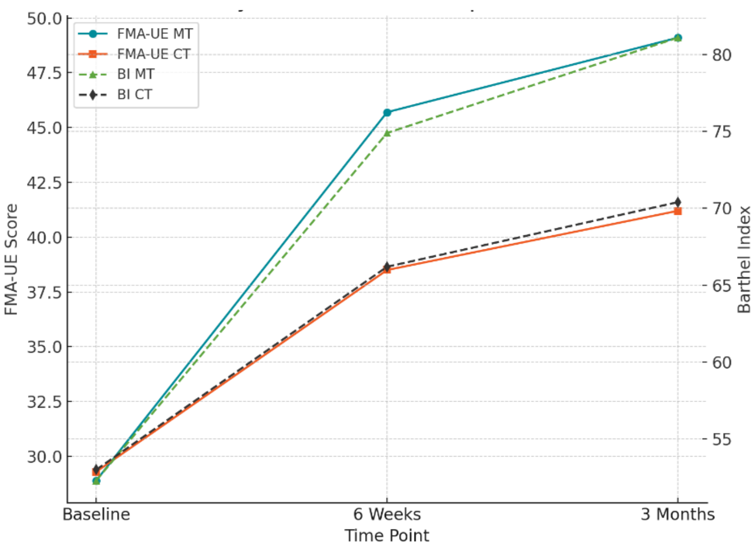

Figure 1 Motor Recovery and Functional Independence Over Time

The integrated visualization shows recovery trends for both groups over time. Mirror Therapy (MT) demonstrated steeper gains in FMA-UE scores, rising from 28.9 at baseline to 49.1 at 3 months, compared with Conventional Therapy (CT), which increased from 29.3 to 41.2. A parallel trend was observed in functional independence: MT improved on the Barthel Index from 52.3 to 81.1, while CT advanced from 53.0 to 70.4. The dual-axis depiction highlights not only the consistent superiority of MT in motor and ADL outcomes but also the widening group difference across time, with clinically meaningful separation evident as early as six weeks and sustained at three months.

DISCUSSION

The findings of this randomized controlled trial demonstrate that mirror therapy (MT) produced significantly greater improvements in upper limb motor function, functional independence, and spasticity reduction compared to conventional therapy (CT) in stroke survivors. Although both groups showed significant within-group improvements over time, the between-group differences consistently favored MT, with effect sizes in the large range for FMA-UE, ARAT, and Barthel Index outcomes. These results reinforce the hypothesis that MT enhances neuroplasticity by engaging mirror neuron networks and facilitating cortical reorganization, thereby augmenting recovery processes beyond the effects of conventional rehabilitation (20).

Our results align with prior evidence demonstrating the clinical benefits of MT. A Cochrane review by Thieme et al. concluded that MT provides meaningful improvements in upper limb motor function post-stroke, particularly when combined with structured rehabilitation programs (21). Similarly, Michielsen et al. reported that MT led to significant cortical reorganization in chronic stroke patients, corresponding to functional gains observed in clinical assessments (22). The present trial extends these findings by demonstrating not only motor improvements but also superior outcomes in ADLs as measured by the Barthel Index, suggesting effective translation of motor recovery into daily functional performance. These functional gains are clinically meaningful, as independence in ADLs strongly predicts long-term quality of life and social reintegration (23).

The reduction in spasticity observed in the MT group is another noteworthy finding. The Modified Ashworth Scale scores declined more markedly in the MT group, consistent with the hypothesis that visual illusions of normal movement modulate abnormal reflex activity and motor output. Lee et al. reported similar reductions in spasticity following MT, supporting its role as a cost-effective adjunct for managing hypertonicity (24). These results are particularly relevant in resource-limited settings such as Pakistan, where access to pharmacological or advanced technological interventions for spasticity management may be restricted.

The clinical implications of these findings are significant. MT requires minimal equipment, is simple to administer, and can be incorporated into both clinic-based and home-based rehabilitation programs. This is especially important in low- and middle-income countries where therapist availability is limited, and rehabilitation access remains a major barrier (25). Furthermore, patient adherence may be enhanced by the engaging nature of MT, as survivors often report improved motivation when observing the visual illusion of normal limb movement. This factor could contribute to sustained participation and improved long-term outcomes compared with traditional repetitive exercises (26).

Despite these strengths, several limitations should be acknowledged. First, the trial was conducted at a single center, which may limit generalizability to broader populations with diverse healthcare infrastructures. Second, the follow-up duration was limited to three months, preventing assessment of long-term sustainability of treatment effects. Third, while home exercise adherence was encouraged, it was monitored only through self-reported logs, which may be prone to bias. Finally, subgroup analyses stratified by stroke chronicity and severity were not performed, which could have revealed differential effects across patient profiles (27).

Future research should aim to validate these findings through larger, multi-center trials with longer follow-up durations to capture sustained outcomes and relapse prevention. Additionally, integrating MT with emerging technologies such as virtual reality, robotic-assisted therapy, or biofeedback-enhanced systems could further optimize rehabilitation strategies. Neuroimaging studies would also provide mechanistic insights into cortical activation patterns, helping to refine patient selection and identify those most likely to benefit from MT (28).

In summary, this study adds to the growing body of evidence supporting the effectiveness of mirror therapy in post-stroke upper limb rehabilitation. Compared to conventional therapy alone, MT produced superior gains in motor recovery, functional independence, and spasticity reduction. These results support the inclusion of MT as a standard component of stroke rehabilitation, particularly in settings where low-cost, scalable interventions are needed to address the high burden of post-stroke disability.

CONCLUSION

The results of this randomized controlled trial demonstrate that mirror therapy is more effective than conventional therapy in improving upper limb motor recovery, enhancing functional independence, and reducing spasticity in stroke survivors. While both interventions produced significant within-group improvements, mirror therapy consistently yielded larger effect sizes and clinically meaningful between-group differences across validated measures including the Fugl–Meyer Assessment, Action Research Arm Test, Barthel Index, and Modified Ashworth Scale. The simplicity, low cost, and adaptability of mirror therapy make it an especially valuable intervention for integration into routine rehabilitation practice in resource-limited healthcare systems. These findings provide evidence-based support for the clinical use of mirror therapy and highlight its potential to reduce long-term disability burden after stroke. Further research should focus on optimizing treatment protocols, assessing long-term outcomes, and exploring synergistic effects when combined with emerging rehabilitation technologies.

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