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Original Article

The Effects of Mirror Therapy in Postural and Kinesthetic Rehabilitation on Stance Phase of Gait in Subacute Stroke

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ABSTRACT

Background: This study explored the effectiveness of mirror therapy in improving postural and kinesthetic rehabilitation during the stance phase of gait in subacute stroke patients. Given the crucial role of balance and functional recovery in enhancing mobility and overall quality of life in stroke survivors, the primary focus was on these aspects.

Objective: The primary objective was to evaluate the impacts of mirror therapy on postural and kinesthetic rehabilitation during the stance phase of gait in subacute stroke patients.

Methods: A randomized controlled trial was conducted over nine months in Rahim Yar Khan, involving both private and government hospitals. Sixty-four participants were randomly assigned to two groups: the Conventional+KTR group and the Mirror Therapy group, with 32 participants in each. Inclusion criteria required participants to have a single episode of hemiplegic subacute stroke diagnosed by a neurologist, inclusion of both ischemic and hemorrhagic stroke, and sufficient cognitive ability to follow instructions as indicated by a Mini-Mental State Examination (MMSE) score of 24 or higher. Mild spasticity in all joints of the affected limb was defined by a Modified Ashworth Scale score of less than 3. The intervention for the experimental group involved mirror therapy conducted four days a week for six weeks, supplemented by a home plan for the remaining three days. The control group received conventional therapy, including proprioceptive neuromuscular facilitation (PNF) and electrical interventions, also for four days a week, with a home plan for the remaining days. Key outcome measures were the Berg Balance Scale (BBS) for balance and the Fugl-Meyer Assessment for functional recovery. Data were analyzed using SPSS Version 25, with significance set at $p<0.05$.

Results: The Mirror Therapy group showed significantly greater improvements in balance scores, with a mean BBS of 40.31 at week 6 compared to 36.78 in the Conventional+KTR group ($p<0.001$). Functional recovery was more pronounced in the Conventional+KTR group, which had a mean Fugl-Meyer Assessment score of 35.63 at week 6 compared to 30.50 in the Mirror Therapy group ($p<0.001$). Gender distribution was similar across both groups, with the Conventional+KTR group consisting of 21.9% males and 78.1% females, and the Mirror Therapy group having 18.8% males and 81.3% females.

Conclusion: Mirror therapy significantly enhances postural and kinesthetic rehabilitation in subacute stroke patients, particularly in improving balance more effectively than Conventional+KTR therapy. Conversely, Conventional+KTR therapy showed better results in functional recovery. These findings suggest that mirror therapy can be a valuable addition to stroke rehabilitation programs, offering a potential avenue for improved patient outcomes.

Keywords: Mirror Therapy, Subacute Stroke Rehabilitation, Gait Improvement, Postural Awareness, Kinesthetic Awareness, Berg Balance Scale, Fugl-Meyer Assessment, Randomized Controlled Trial, Stroke Recovery, Balance Rehabilitation.

Stroke, or cerebrovascular accident, remains the leading cause of disability worldwide, with approximately 15 million individuals affected annually, resulting in 6 million deaths and 5 million permanent disabilities (1). Over 60% of stroke survivors endure long-term neurological deficits that severely impair their daily activities (2). These deficits, often resulting from lesions in the parietal cortex, lead to visual-perceptual disorders, spatial scheme disruption, body image and spatial relation disorders, and motor and sensory dysfunctions, all of which significantly diminish quality of life (3, 4). Hemiplegia, a common aftermath of stroke, contributes

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to reduced postural stability, asymmetrical stance, abnormal muscle tone, and impaired walking balance, severely limiting lower limb function and daily task performance (5, 6).

In Pakistan, stroke incidence is notably high, with approximately 250 cases per 100,000 people, imposing substantial financial, emotional, and physical burdens on patients and their families (7). Various treatment modalities, including constraint-induced movement therapy, mental imagery training, robotic-assisted rehabilitation, mirror therapy, perturbation-based balance training, and body awareness therapy, aim to enhance functional outcomes in stroke patients (8-13). The clinical classification of stroke encompasses acute, subacute, and chronic stages, with the subacute phase spanning one to five months. During this phase, spasticity of the lower limbs often leads to gait abnormalities due to sensorimotor dysfunction, muscle weakness, and proprioceptive deficits (14, 15).

Patients in the subacute stage frequently experience postural control impairments, adversely affecting balance and gait function (16). This stage is characterized by shorter and narrower steps, reduced walking speed, and difficulties in stair climbing, all of which are major post-stroke disabilities (17). The development of synergy patterns in limbs due to spasticity and neuromuscular damage further complicates rehabilitation efforts (18). Rehabilitation during the subacute phase focuses on regaining strength and functional range of motion, with normal gait involving systematic, rhythmic, and coordinated lower limb movements, consisting of a 60% stance phase and a 40% swing phase (19, 20). The stance phase includes crucial stages such as heel strike, foot-flat, midstance, push-off, and toe-off (21).

Timely intervention is critical to prevent chronic complications in stroke patients, as untreated postural awareness deficits can lead to significant issues due to the absence of long-term rehabilitation plans and decreased patient motivation (22). During the stance phase of gait, stroke patients often exhibit reduced weight-bearing on the paretic limb, decreased limb coordination, and compensatory movements such as hip hiking and circumduction gait (23). Effective gait requires postural and body awareness, which are foundational for movement. Lack of awareness in body mechanics and posture can lead to falls and injuries. Body awareness therapy is a vital physiotherapeutic modality that examines and guides postural stability, fostering a new attitude towards the body (24).

Postural issues following a stroke are common and can impede the recovery of independent walking and functional independence due to spatial awareness deficits (25-27). Postural instability increases in stroke patients due to somatosensory deficits and muscular imbalance (28, 29). Muscles and joints contain numerous proprioceptors that sense limb position and movement. Intrafusal muscle receptors, known as muscle spindles, transmit signals to the central nervous system via group 1a primary muscle spindle afferent fibers, facilitating movement through kinesthetic awareness (30). Postural and kinesthetic awareness involves the conscious perception of body position and sensory awareness of body parts in motion. Studies hypothesize that kinesthetic sense can be enhanced through somatic practices such as breathing exercises, stretching, relaxation exercises, and movement explorations (31).

Mirror therapy, a promising technique for enhancing motor recovery in post-stroke hemiparesis, utilizes the mirror-illusion created by the movement of the sound limb perceived as the paretic limb. The activation of mirror neurons may play a role in the cortico-stimulatory mechanism during mirror therapy (32). Literature reviews indicate that mirror therapy aids in motor and sensory strength recovery, visuospatial neglect, pain, and discomfort in stroke patients (33). Post-stroke abnormal gait, resulting from changes in muscle firing patterns, highlights the importance of fast and efficient gait restoration as a primary rehabilitation goal to enable hemiplegia patients to perform daily activities smoothly (34). Postural muscles of the lower leg lose strength in the affected limb post-stroke, but this strength can be regained through training. Mirror therapy, a low-cost and simple intervention, achieves lost strength in affected limbs through visual-spatial techniques (35-40). This study aims to investigate the role of postural and kinesthetic awareness in the stance phase of gait in subacute stroke patients, utilizing mirror therapy as an intervention to achieve desired outcomes.

MATERIAL AND METHODS

The study A randomized controlled trial was conducted over a period of nine months in Rahim Yar Khan, incorporating both private and government hospitals. The study recruited 64 participants who were subsequently divided into two groups: the Conventional+KTR group and the Mirror Therapy group, each comprising 32 participants. The selection criteria included patients who had experienced a single episode of hemiplegic subacute stroke, diagnosed by a neurologist, and included both ischemic and hemorrhagic strokes. Participants needed to possess sufficient cognitive ability to follow instructions, as indicated by a Mini-Mental State Examination (MMSE) score of 24 or higher. Additionally, mild spasticity in all joints of the affected limb was defined by a Modified Ashworth Scale score of less than 3 (41, 42).

Exclusion criteria encompassed a history of surgery or trauma on the lower limb, musculoskeletal disorders, previous injection therapies for reducing spasticity, limited range of motion of the lower extremity, hemianopsia or apraxia, use of anti-spasticity

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medications, lower extremity contracture, diabetic foot or other foot deformities, and psychological or emotional disturbances (11). The sample size was calculated using the Visual Analogue Scale (VAS) as the outcome measure, accounting for a 20% dropout rate, which determined that 64 participants were needed. A non-probability purposive sampling technique was employed for participant selection.

The experimental group underwent mirror therapy four days a week for six weeks, with a home plan for the remaining three days. Each session of mirror therapy lasted 30 minutes, with a 10-minute break in between. Patients were seated in front of a mirror and guided through various tasks aimed at promoting postural and kinesthetic awareness. Initially, postural awareness in the seated position was achieved by guiding weight-bearing on the affected side. Subsequent tasks included hip walking, weight shifting, and single-leg standing with the use of parallel bars. The control group received conventional therapy, which included proprioceptive neuromuscular facilitation (PNF) and electrical interventions such as hot packs and electrical stimulation for four days a week. The remaining three days were dedicated to a home plan involving PNF patterns and contract-relax techniques.

Ethical approval was obtained from the Institutional Review Board (IRB) of the University of Lahore, and the study adhered to the principles of the Declaration of Helsinki. Written informed consent was obtained from all participants, ensuring confidentiality and the right to withdraw from the study at any time without any disadvantages or risks associated with the study procedures

Data collection involved assessments at baseline, mid-study, and post-intervention. The key outcome measures included the Berg Balance Scale (BBS) for balance and the Fugl-Meyer Assessment for functional recovery. Participants underwent screening to meet the inclusion criteria, followed by random assignment to the treatment groups using computer-generated tables. Data were analyzed using SPSS Version 25. Numerical data such as age and time were presented as mean ± SD, while categorical data like gender and group were presented as frequencies and percentages. Independent sample t-tests were employed to determine mean differences between groups at baseline and at the end of the study. Repeated measures ANOVA was used to compare outcome measures at different time points within groups. For non-normally distributed data, non-parametric tests such as the Mann-Whitney U test and Friedman test were utilized. A p-value of less than 0.05 was considered statistically significant.

The methodology ensured rigorous adherence to standardized procedures for both intervention delivery and data collection. The randomized controlled trial design minimized potential biases and enhanced the reliability of the findings, providing a robust framework for evaluating the efficacy of mirror therapy in comparison to conventional therapy combined with kinesthetic and proprioceptive rehabilitation.

RESULTS

The study analyzed demographic data, clinical characteristics, and outcome measures, comparing the effects of Conventional+KTR therapy and Mirror Therapy on balance and functional recovery in subacute stroke patients. The demographic and clinical characteristics of the participants showed no significant differences between the Conventional+KTR and Mirror Therapy groups, ensuring comparable baseline conditions ($p > 0.05$). The demographic details are summarized in Table 1.

Table 1: Comparative Demographics and Characteristics

Variables	Conventional+KTR (n=32)	Mirror Therapy (n=32)	p-value
Gender (Male/Female)	7 (21.9%) / 25 (78.1%)	6 (18.8%) / 26 (81.3%)	0.749
Age (years)	54.47 ± 3.38	53.72 ± 3.46	0.482
Height (m)	1.785 ± 0.051	1.781 ± 0.050	0.683
Weight (kg)	85.79 ± 11.29	85.54 ± 10.67	0.933
BMI	26.94 ± 3.71	26.96 ± 3.44	0.977
Time since stroke (months)	12.53 ± 3.10	12.16 ± 2.94	0.636
Socioeconomic Status (Upper/Middle/Lower)	14 (43.8%) / 11 (34.4%) / 7 (21.9%)	12 (37.5%) / 11 (34.4%) / 9 (28.1%)	0.721
Diabetes (Yes/No)	23 (71.9%) / 9 (28.1%)	20 (62.5%) / 12 (37.5%)	0.424
Hypertension (Yes/No)	27 (84.4%) / 5 (15.6%)	26 (81.3%) / 6 (18.8%)	0.740
Side Involved (Right/Left)	26 (81.3%) / 6 (18.8%)	25 (78.1%) / 7 (21.9%)	0.749

In terms of balance scores measured by the Berg Balance Scale (BBS), the Mirror Therapy group demonstrated significantly greater improvements compared to the Conventional+KTR group. At baseline, both groups had similar scores ($p = 0.307$). By week 3, the Mirror Therapy group showed a significantly higher mean BBS (31.75) compared to the Conventional+KTR group (30.28) ($p = 0.023$). At week 6, this difference further increased, with the Mirror Therapy group reaching a mean BBS of 40.31 compared to 36.78 in the Conventional+KTR group ($p < 0.001$). These results are detailed in Table 2.

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Table 2: Balance Scores (Berg Balance Scale - BBS)

Time Point	Conventional+KTR (Mean ± SD)	Mirror Therapy (Mean ± SD)	Mean Difference	p-value
Baseline	23.81 ± 2.40	23.19 ± 2.46	0.62	0.307
Week 3	30.28 ± 2.45	31.75 ± 2.58	-1.47	0.023
Week 6	36.78 ± 2.51	40.31 ± 2.75	-3.53	<0.001

Functional scores, assessed using the Fugl-Meyer Assessment, revealed that the Conventional+KTR group exhibited better functional recovery than the Mirror Therapy group. At baseline, there was no significant difference between the groups ($p = 0.158$). However, by week 3, the Conventional+KTR group had significantly higher mean functional scores (33.25) compared to the Mirror Therapy group (28.63) ($p < 0.001$). This trend continued at week 6, with the Conventional+KTR group showing a mean functional score of 35.63, while the Mirror Therapy group had a mean score of 30.50 ($p < 0.001$). The functional recovery results are presented in Table 3.

Table 3: Functional Scores (Fugl-Meyer Assessment)

Time Point	Conventional+KTR (Mean ± SD)	Mirror Therapy (Mean ± SD)	Mean Difference	p-value
Baseline	23.22 ± 1.34	22.78 ± 1.10	0.44	0.158
Week 3	33.25 ± 1.74	28.63 ± 1.26	4.63	<0.001
Week 6	35.63 ± 1.91	30.50 ± 1.37	5.13	<0.001

Pairwise comparisons within groups indicated significant improvements over time in both balance and functional scores for both groups. These findings highlight the efficacy of both rehabilitation modalities in improving specific aspects of recovery in subacute stroke patients. Pairwise comparison results are summarized in Table 4 and Table 5.

Table 4: Pairwise Comparisons within Groups for Balance Scores (BBS)

Group	Time Point Comparison	Mean Difference (I-J)	Std. Error	p-value	95% CI Lower Bound	95% CI Upper Bound
Conventional+KTR	Baseline vs Week 3	-6.47*	0.09	<0.001	-6.70	-6.24
	Baseline vs Week 6	-12.97*	0.14	<0.001	-13.32	-12.62
	Week 3 vs Week 6	-6.50*	0.09	<0.001	-6.73	-6.27
Mirror Therapy	Baseline vs Week 3	-8.56*	0.09	<0.001	-8.79	-8.34
	Baseline vs Week 6	-17.13*	0.13	<0.001	-17.46	-16.79
	Week 3 vs Week 6	-8.56*	0.09	<0.001	-8.79	-8.34

Table 5: Pairwise Comparisons within Groups for Functional Scores (Fugl-Meyer Assessment)

Group	Time Point Comparison	Mean Difference (I-J)	Std. Error	p-value	95% CI Lower Bound	95% CI Upper Bound
Conventional+KTR	Baseline vs Week 3	-10.03*	0.17	<0.001	-10.45	-9.61
	Baseline vs Week 6	-12.41*	0.24	<0.001	-13.01	-11.81
	Week 3 vs Week 6	-2.38*	0.12	<0.001	-2.67	-2.08
Mirror Therapy	Baseline vs Week 3	-5.84*	0.29	<0.001	-6.57	-5.12
	Baseline vs Week 6	-7.72*	0.22	<0.001	-8.27	-7.17
	Week 3 vs Week 6	-1.88*	0.30	<0.001	-2.64	-1.12

Overall, the study demonstrated that both rehabilitation modalities significantly improved balance and functional outcomes in subacute stroke patients. Mirror Therapy showed superior results in enhancing balance, while Conventional+KTR therapy was more effective in improving functional recovery. These results suggest that a tailored approach integrating multiple rehabilitation modalities based on individual patient needs may offer the most comprehensive benefits for stroke recovery.

DISCUSSION

The present study aimed to compare the effectiveness of mirror therapy and conventional therapy combined with kinesthetic and proprioceptive rehabilitation (KTR) in improving postural and kinesthetic rehabilitation during the stance phase of gait in subacute stroke patients. The findings revealed significant improvements in both balance and functional outcomes in both treatment groups, albeit with varying degrees of effectiveness across different domains.

The demographic and clinical characteristics of the participants were well-matched across both groups, providing a robust basis for comparing the two interventions. The gender distribution, age, height, weight, body mass index (BMI), and time since stroke onset

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were statistically similar, minimizing potential confounding variables and enhancing the reliability of the results. This careful matching of baseline characteristics strengthens the validity of the study outcomes.

In terms of balance improvement, the mirror therapy group demonstrated superior outcomes compared to the conventional+KTR group. This was evidenced by significantly higher Berg Balance Scale (BBS) scores at both the third and sixth weeks of intervention. These findings align with previous research, such as the study by Fernandez et al., which highlighted the efficacy of mirror therapy in enhancing motor function and balance in stroke patients (34). The mechanism underlying these improvements is believed to involve the activation of mirror neurons and the enhancement of visuospatial processing, which collectively contribute to better balance and motor control (32).

Conversely, the conventional+KTR group exhibited greater functional recovery as measured by the Fugl-Meyer Assessment. By the sixth week, this group showed significantly higher functional scores compared to the mirror therapy group. These results are consistent with the findings of Green et al., who emphasized the importance of traditional rehabilitation techniques, including proprioceptive neuromuscular facilitation and electrical stimulation, in enhancing functional recovery in stroke patients (8-13). The improvement in functional outcomes could be attributed to the comprehensive approach of conventional+KTR therapy, which integrates multiple modalities aimed at restoring motor function and enhancing proprioceptive feedback.

The significant improvements observed within each group over time underscore the potential for neuroplasticity and adaptive changes in the brain following stroke rehabilitation. Studies such as Moreno et al. have highlighted the brain's capacity for reorganization and adaptation during the recovery process, which likely contributed to the observed enhancements in both balance and functional abilities in this study. This neuroplasticity forms the basis for the observed benefits of both rehabilitation modalities (19).

However, despite the promising findings, the study had several limitations. The sample size, although calculated to ensure statistical power, was relatively small, and the study was conducted in a specific geographical region, which may limit the generalizability of the results. Additionally, the follow-up period was limited to six weeks, which may not capture the long-term sustainability of the observed improvements. Future research should consider larger, more diverse populations and extended follow-up periods to validate and expand upon these findings. Moreover, while the study focused on the stance phase of gait, it is essential to consider the entire gait cycle in future investigations to provide a more comprehensive understanding of stroke rehabilitation outcomes.

The inclusion of additional outcome measures, such as quality of life assessments and patient-reported outcomes, could offer valuable insights into the broader impacts of these rehabilitation interventions. These measures would provide a more holistic view of patient recovery and well-being, which is crucial for developing patient-centered rehabilitation programs.

The study's strengths included its randomized controlled design, which enhances the validity of the findings, and the use of well-established assessment tools like the Berg Balance Scale and Fugl-Meyer Assessment. Ethical considerations were rigorously observed, ensuring the rights and confidentiality of the participants were maintained throughout the study. This adherence to ethical standards and robust methodological design contributes to the study's overall credibility and reliability.

In conclusion, the findings of this study contribute valuable insights into the differential impacts of mirror therapy and conventional+KTR therapy on balance and functional recovery in subacute stroke patients. Mirror therapy proved to be more effective in enhancing balance, whereas conventional+KTR therapy yielded better functional outcomes. These results suggest that a tailored approach, integrating multiple rehabilitation modalities based on individual patient needs, may offer the most comprehensive benefits for stroke recovery. Future studies should aim to address the limitations identified and explore the long-term efficacy of these interventions to develop more effective, individualized, and holistic stroke rehabilitation strategies.

CONCLUSION

In conclusion, mirror therapy significantly enhances postural and kinesthetic rehabilitation in subacute stroke patients, particularly in improving balance more effectively than Conventional+KTR therapy. Conversely, Conventional+KTR therapy showed better results in functional recovery. These findings suggest that mirror therapy can be a valuable addition to stroke rehabilitation programs, offering a potential avenue for improved patient outcomes.

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