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A Randomized Controlled Trial: Evaluating the Impact of Mirror Therapy on Mobility, Motor Recovery, and Functional Independence after Stroke

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ABSTRACT

Background: Stroke is a leading cause of long-term disability, impairing motor and functional capacities. Stroke rehabilitation focuses on regaining independence, yet the most effective interventions remain under study. This randomized controlled trial evaluated the efficacy of structured mirror therapy (MT) compared to general physiotherapy exercise over 24 weeks.

Methods: A total of 100 stroke survivors were randomized into two groups: the MT group (n = 50) and the general physiotherapy exercises group (n = 50). The MT group received 5 times, 15-minute daily sessions for 21 consecutive days. The intervention was administered until the patient was discharged, and the patient was followed up in a community setting if their hospital stay was less than 21 days. Post-tests were conducted at discharge, with follow-ups via phone every 15 days and formal assessments at weeks 6, 12, and 24. Primary outcomes included the Barthel Index (BI) for functional independence and the Rivermead Motor Function Assessment (RMFA) for motor recovery of mobility.

Results: Baseline characteristics were broadly similar, though the MT group had higher education, more skilled occupations, and more severe ischemic strokes. The MT group showed notably better improvements, with BI increasing from 13.02 to 27.78, compared to 15.10 to 22.82 in controls ($P < 0.001$), while RMFA improved from 43.54 to 76.00, compared to 49.44 to 70.08 ($P < 0.001$). Repeated-measures ANOVA confirmed significant group differences (BI: $F = 84.759$, $P < 0.001$; RMFA: $F = 302.679$, $P < 0.001$). Subgroup analyses revealed better outcomes with early MT initiation (within 7 days) in ischemic stroke cases.

Conclusion: Structured MT significantly enhances motor and functional recovery post-stroke, independent of sociodemographic factors. Integrating MT into routine rehabilitation could improve recovery, reduce caregiver burden, and boost quality of life. Long-term studies are warranted.

Trial Registration: Clinical Trial Registry India, CTRI/2023/07/054998

Keywords: Stroke, Mirror Therapy, Functional Independence, Mobility Motor Recovery, Randomized Controlled Trial.

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INTRODUCTION

Stroke is a leading cause of long-standing disability globally, with significant consequences for individuals' mobility and functional independence. It is estimated that approximately 25% of individuals aged 25 and older worldwide will experience a stroke in their adult lives, with an increasing risk among the elderly population [1]. Aging, one of the primary risk factors, especially for individuals over the age of 55, is a significant factor that cannot be changed, and the incidence of stroke is expected to rise as the number of individuals aged 65 and older increases [2]. The prevalence of stroke is compounded by the impact of COVID-19, which has been shown to increase the risk of ischemic stroke, exacerbating the global burden of the condition [1]. Moreover, stroke survivors often face a range of impairments, particularly affecting the upper limbs, with around 85% of survivors experiencing hemiplegia, and 69% encountering functional limitations in their upper extremities [2]. This can significantly impair their ability to perform activities of daily living (ADLs) and instrumental activities of daily living (IADLs), resulting in a reduced quality of life and increased dependency.

A stroke, which occurs due to a disruption in the brain's blood supply—either through ischemia or bleeding—can lead to significant neurological impairments. The World Health Organization (WHO) defines a stroke as a cerebrovascular-related neurological deficiency that may result in death within 24 hours or cause lasting damage. The basic symptoms of a stroke include motor and sensory deficits, cognitive impairment, speech difficulties, dizziness, imbalance, and blurred vision [3]. These impairments, particularly those affecting the upper limbs, contribute significantly to post-stroke disability. Approximately 80% of stroke survivors face motor impairments, with half of these individuals also experiencing upper limb pain within the first year after the event [4]. Traditional rehabilitation therapies have made some progress, but many stroke survivors still struggle with regaining full motor function in the affected limbs, with conventional methods often proving inadequate [5].

New and affordable methods for rehabilitation, like mirror therapy, are being investigated to tackle obstacles in stroke recovery. Initially designed for phantom limb pain, mirror therapy utilizes a mirror to simulate regular limb motion visually [6]. This technique has shown promise in enhancing neuroplasticity and restoring motor functions through the stimulation of mirror neuron pathways [7,8]. Despite its accessibility and affordability, further research is required to establish its effectiveness and integration into clinical practice.

The increasing incidence of stroke, especially in aging populations, highlights the urgent need for effective rehabilitation strategies to enhance functional outcomes among stroke survivors with upper limb impairments. Motor dysfunction, like hemiparesis, affects most survivors, impacting autonomy and standard of well-being [9]. Strokes, influenced by various factors, can lead to motor, sensory, and language impairments, which in turn affect independence. Around 88% of elderly stroke survivors experience decreased motor function, impacting daily activities and standard of living [10]. The limited accessibility and affordability of existing therapies underscore the need for more cost-effective and widely available treatment options for motor recovery [11].

Mirror therapy, a cost-effective option, shows promise in helping stroke survivors recover motor function by stimulating brain motor areas through visual feedback [8, 12]. Around 85% of individuals who have had a stroke suffer from hemiparesis, and between 55% and 75% of them still encounter difficulties in using their upper limbs [13]. Despite its potential, further research is needed to determine its effectiveness and application in clinical practice for upper limb recovery.

This research aimed to address this gap by studying how mirror therapy can enhance motor function recovery and independence in daily activities for stroke survivors through a randomized controlled trial. By assessing the effects of mirror therapy, the goal was to understand any association between motor function and independence in daily activities, as well as the impact of socio-demographic and clinical variables. Therefore, the primary research question for this trial was: How does mirror therapy compare to traditional rehabilitation in improving motor function and functional independence, and what associations can be made between its results and socio-demographic and clinical variables?

METHOD

Design

A randomized controlled trial was conducted using a pre-test-post-test design. All stroke survivors who met the study's inclusion criteria were involved in the study. Approval was obtained through the appropriate authorities and ethics committees for the trial. The study was conducted in a tertiary care hospital, and all relevant government regulations regarding the ethical use of study participants were adhered to and implemented in the Medicine and Neurology Department of a tertiary care hospital in Patna, Bihar, India. A secure and safe environment was established prior to the trial's commencement, and eligible study participants were thoroughly screened during the enrolment process. The allocation schedule was concealed from study participants and randomly assigned to either the interventional group (n = 50) or the comparison group (n = 50) using a blocked randomization method.

Participants

Stroke survivors aged 18 and above, diagnosed with either cerebral infarction or hemorrhage, and admitted to a tertiary care hospital were enrolled over 12 months from December 2023 to November 2024. The intervention was provided until the patient was discharged from the hospital, with follow-up care in the community setting if the patient's hospital stay was less than 21 days. Patients who were not in acute coma or not in need of ventilatory support and were willing to undergo the suggested interventions were considered. Exclusions were individuals who declined to participate, individuals with significant comorbidities (such as severe circulatory, digestive, blood, or endocrine disorders), acute conditions (like epilepsy), mental health disorders (such as schizophrenia or psychosis), and pre-existing disabilities. Participants who were not present during the intervention and data collection periods were also deemed ineligible for the study.

The progression of the study through the trial stages is illustrated in Figure 1. Throughout the study, 485 patients were admitted. Of these, 260 were excluded at the initial screening because they were in a moribund condition; additionally, 47 patients refused to participate, 53 were unable to join due to their families' time limitations, and 25 had other comorbidities that barred their inclusion. Consequently, 100 patients met the eligibility requirements and agreed to participate, constituting the final sample for the study.

Statistical Analysis

The sample size was determined a priori by computing the required sample size using G*Power analysis, with an F-test for repeated measures ANOVA. The primary outcome was the comparison between factors affecting daily living activities and motor function for mobility. In brief, the calculation took alpha (significance level) as 0.05, standard power (1-β error probability) as 0.80 (80%), effect size (f) as 0.25, number of groups as two (2), number of measurements as 5, correlation among repeated measures as 0.5 and no sphericity correction (epsilon) as 1. The calculation indicated that approximately 80 samples would be required for the study. The investigator included 100 samples in the study. The study's findings were analyzed using the SPSS 27 software package.

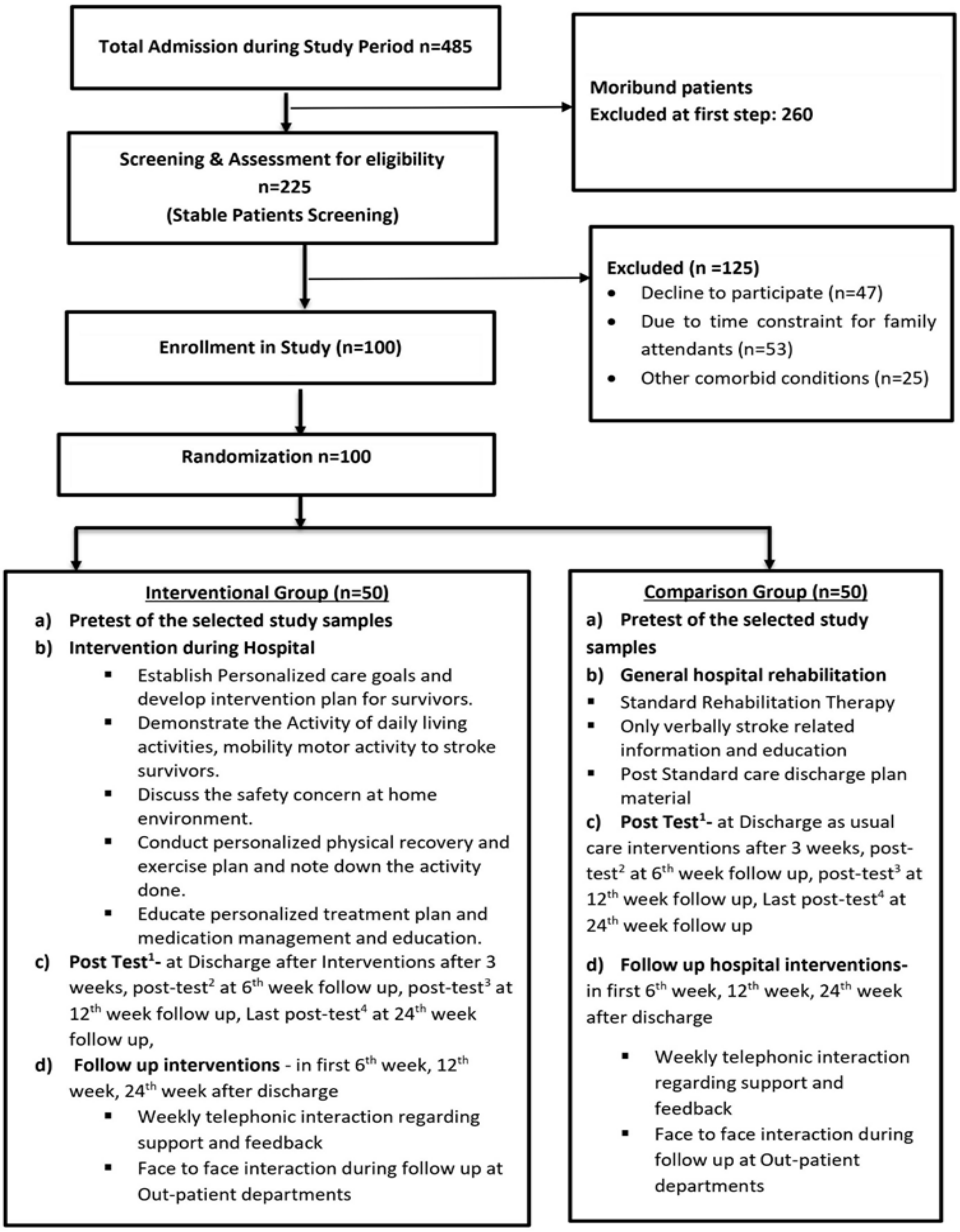

Figure 1: Flow of the study process

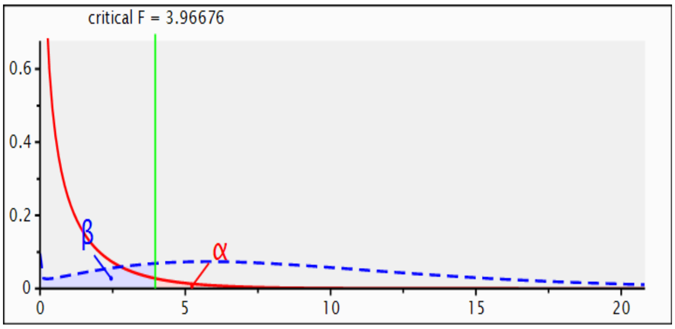

Figure 2: G* Power Analysis for sample size calculation

Interventions

Interventional group

Participants in the intervention group received mirror therapy treatments, which involved using a mirror to create a visual illusion of movement in the affected limb. Hemiplegic individuals underwent this therapy, which targeted specific tasks (involving wrist and elbow flexor and extensor movements for the upper limb, as well as lower limb exercises), during 15-minute sessions, five times a day, for 21 days, until discharge, in accordance with the hospital's guidelines. Stroke patients were seated comfortably and monitored throughout the therapy sessions. A vertical mirror (measuring 60 × 30 cm) was placed on the desk in a vertical position. The paralyzed limb was positioned behind the mirror, while the unaffected limb was placed in front of the mirror, giving the impression that the affected hand was in motion [14]. If more than one implication was chosen to get benefits from such training, which was directly and indirectly based upon the clinician's subjective judgment after considering relevant factors.

The mirror therapy intervention was demonstrated by the principal investigator, and during each session, study participants performed repetitions for at least a defined 15 minutes 5 times a day, as well as usual therapy sessions. During each session, participants were given rest if they fatigued and encouraged to take a brief recuperation of 3-4 minutes between each session set of 5 repetitions. The information on mirror therapy interventions was recorded in a dedicated diary after each session. Four (4) Post-test evaluations for both groups were conducted using the Barthel Index and Rivermead Motor Function assessment at discharge and while coming for the stipulated follow-up at the 6th week, 12th week, and final 24th week.

Comparison group

Participants in the comparison group received usual care, standard hospital rehabilitation interventions, and general physiotherapy exercises as per hospital protocol.

Outcome Measures

The study evaluated improvements in mobility, motor function, and daily living activities following mirror therapy using standardized tools: the Rivermead Motor Function Assessment (RMFA) and the Barthel Index (BI).

Socio-demographic and clinical characteristics

Baseline socio-demographic and clinical data were collected through face-to-face interviews using a 17-item questionnaire.

Barthel Index for daily living activities (functional independence)

The Barthel Index assessed functional independence through 10 activities, including feeding, bathing, dressing, toileting, mobility, and stair use. The ratings varied from 0 to 15 for each item, with higher scores reflecting increased levels of independence. A post-test was conducted at the end of the trial to assess participants' progress.

Rivermead Motor Function Assessment (RMFA) for Mobility motor function

The RMFA evaluated motor function across three sections: (A) gross functions (13 items), (B) leg and trunk functions (10 items), and (C) arm functions (15 items). Responses were scored as 0 (unable to perform) or 1 (able to perform). Each item was attempted three times, with gross and arm function testing discontinued after three consecutive zero scores, whereas all leg and trunk function items were assessed. These standardized tools ensured consistent evaluation of participants' mobility and functional improvements.

RESULTS

Trial Adherence

The intended sample size was obtained and analysed, with 50 in each group. The prospective registered outcome measures were collected. There were no serious adverse events related to the intervention reported. Study participants' compliance with the experimental intervention is discussed further.

According to the trial protocol, individuals in the interventional group were instructed to engage in 15-minute mirror therapy sessions, five times a day, for three weeks (21 days) under supervision. All participants in the intervention group underwent consistent mirror therapy interventions, without any breaks for public holidays.

Table 1: Baseline Socio-demographic characteristics of stroke survivors

S N	Baseline Characteristics	Interven-tional (n=50)	Compar-ison (n=50)	Chi-Square (χ^2)	P Value
1.	**Age**				
	41-55	15 (30%)	09 (18%)	3.153	0.207
	56-70	34 (68%)	41 (82%)		
	Above 70	01 (2%)	00 (-)		
2.	**Gender**				
	Male	36(72%)	41(82%)	1.412	0.235
	Female	14 (28%)	09(18%)		
3.	**Marital Status**				
	Married	38(76%)	34 (68%)	0.794	0.373
	Widower /Widow	12(24%)	16(32%)		
4.	**Religion**				
	Hindu	46(92%)	41 (82%)	2.210	0.137
	Muslim	04(8%)	09(18%)		

5.	**Types of Family**				
	Joint	35(70%)	26(52%)	3.405	0.065
	Nuclear	15(30%)	24(48%)		
6.	**Area of Dwelling**				
	Rural	30 (60%)	28(56%)	0.164	0.685
	Semi Urban	20(40%)	22 (44%)		
7.	**Educational Status**				
	Illiterate	07(14%)	19 (38%)	14.004	0.007
	Primary, Middle School Level	04 (8%)	10(20%)		
	Secondary Level	19 (38%)	10 (20%)		
	Higher Secondary School Level	10 (20%)	07 (14%)		
	Graduate and Above Level	10(10%)	04 (8%)		
8.	**Occupational Status**				
	Skilled	37(74%)	32 (64%)	1.169	0.280
	Unskilled	13(26%)	18 (36%)		
9.	**Total Monthly Family Income (Rs.)**				
	Less than 6000	0 (-)	01(2%)	2.151	0.708
	6001-18000	05 (10%)	07(14%)		
	18001-31000	21 (42%)	20 (40%)		
	31001-46000	16 (32%)	12(24%)		
	46001-60000 Above	08 (16%)	10 (20%)		
10	**Family members**				
	2 Two or Three (3)	19 (38%)	27 (54%)	4.018	0.260
	Four (4)	25 (50%)	19(38%)		
	Five and More than Five	06 (12%)	4(8%)		
11.	**Any Insurance Facility available**				
	No other medical insurance	28 (56 %)	23 (46%)	1.000	0.317
	Govt Medical Insurance Scheme	22 (44%)	27(54%)		
12.	**Substance Abuse**				
	Tobacco	16 (32%)	16 (32%0	10.087	0.018
	Alcohol	0 (-)	06 (12%)		
	Both Tobacco and Alcohol	22 (44%)	24 (48%)		
	None of the above	12 (24%)	04 (8%)		

P value- test of significance

Table 1 presents the baseline socio-demographic characteristics of stroke survivors in the interventional and comparison groups. Variables such as age, gender, marital status, education, occupational status, income, insurance availability, and substance abuse were assessed. Predominant age distribution was (56–70 years), while most variables were comparable between groups, a significant difference was observed in substance abuse pattern (P=0.018). The importance of analysing such baseline characteristics lies in their potential influence on stroke outcomes and rehabilitation adherence [15]. The percentage of illiterates was significantly higher in the comparison group (38% vs. 14%). Education status, income, and insurance status are related to healthcare access and stroke recovery trajectories [16]. Regarding substance use, both groups had similar proportions, with tobacco and alcohol being the most prevalent. The intervention group had a higher average monthly income and a lower proportion of small families (2–3 members). Additionally, substance abuse was recognized as a modifiable risk factor influencing both stroke incidence and post-stroke recovery [17].

Table 2: Clinical characteristics of stroke survivors

S N	Clinical Characteristic	Interventional (n=50)	Comparison (n=50)	Chi-Square (χ^2)	P Value
1.	**Types of strokes**				
	Ischemic Stroke	35 (70%)	29 (58%)	1.563	0.211
	Haemorrhagic Stroke	15 (30%)	21 (42%)		
2.	**Suffering from a stroke since**				
	0-7 days	36 (72%)	25 (50%)	16.041	0.001
	8-14 days	29 (58%)	20 (40%)		
	15-30 days	14 (28%)	05 (10%)		
3.	**Location of any disability**				
	Right Upper Limb	01 (2%)	03 (6%)	2.221	0.528
	Left Upper Limb	20 (40%)	24 (48%)		
	Right Upper - Lower extremity	05 (10%)	5 (10%)		
	Left Upper- Lower extremity	24 (48%)	18(36%)		
4.	**Severity of stroke as per clinical assessment**				
	Mild	00 (-)	09 (18%)	18.688	0.001
	Mild to Moderate	21 (42%)	30 (60%)		
	Severe	29 (58%)	11 (22%)		
5.	**Any Comorbidity**				
	Hypertension	12 (24%)	11 (22%)	0.081	0.961
	Diabetes	13(26%)	14 (28%)		
	Hypertension and diabetes	25 (50%)	25 (50%)		

Sig. - P value- test of significance

Table 2 outlines the clinical characteristics of the participants. At the same time, the distribution of stroke types and limb disabilities did not differ significantly between groups; however, statistically significant differences were observed in the duration since stroke onset (P = 0.001) and in clinical severity (P = 0.001). Clinical parameters such as time since stroke, affected limbs, and comorbid conditions are known to influence recovery and functional outcomes after stroke [18, 19]. Timely initiation of rehabilitation, particularly in the early phases post-stroke, is associated with improved neuroplasticity and recovery [20]. Moreover, stroke severity and the presence of comorbidities like hypertension and diabetes play crucial roles in shaping the recovery trajectory [21, 22].

Table 3: Description of Barthel Index scores on Activity of daily living among interventional and comparison groups through Repeated Measures ANOVA (RM-ANOVA)

Observations and Follow up	Interventional Group				Comparison Group			
	Mean	SD	F Value	P Value	Mean	SD	F Value	P Value
Pre-test	13.02	1.220	1017.95	0.001	15.10	1.474	244.792	0.001
Post -test at Discharge	15.40	1.807			16.40	2.277		
Post-test at 6th Week	18.08	1.576			17.72	1.819		
Post-test at 12th Week	22.72	1.325			20.70	1.432		
Post test at 24th Week	27.78	1.075			22.82	1.548		

F value- RM ANOVA Value, P value- test of significance, SD- Standard Deviation

Table no 3 shows, evaluating an interventional group with a comparison group at various time points. The pre-test results show that the interventional group had a lower mean score (13.02) compared to the comparison group (15.10), with significant differences indicated by a p-value of 0.001. As the study progressed to post-tests at discharge, 6th week follow-up, 12th week follow-up, and 24th week follow-up, the interventional group consistently exhibited higher mean scores than the comparison group. Similarly, this study analyses the uses of statistical procedures in 5 Iranian experimental research design, highlighting the prevalence and suitability of ANOVA and ANCOVA in such studies emphasizing its power in detecting differences when they exist [23]. The trend suggests that the implemented intervention had a progressive impact on the measured outcome.

Table 4: Repeated measures ANOVA in interventional and comparison groups for Rivermead motor function assessment

Observations Follow up	Interventional Group				Comparison Group			
	Mean	SD	F Value	P Value	Mean	SD	F Value	P Value
Pre-test	43.54	6.418	302.679	0.001	49.44	10.510	84.759	0.001
Post -test at Discharge	49.44	6.370			54.68	9.518		
Post-test at 6th Week	59.38	5.062			62.18	6.853		
Post-test at 12th Week	67.30	3.593			65.82	5.298		
Post test at 24th Week	76.00	0.000			70.08	3.607		

F value- RM ANOVA Value, P value- test of significance, SD- Standard Deviation

Table 4 presents a comparison of the results between the interventional group and the comparison group at various time points. In the pre-test phase, the interventional group had a mean score of 43.54 with a standard deviation of 6.418, while the comparison group had a mean score of 49.44 with a higher standard deviation of 10.510. There were noteworthy distinctions noted between the two groups, with a P-value of 0.001. Subsequent post-tests at discharge, 6th week follow-up, 12th week follow-up, and 24th week follow-up consistently showed higher mean scores for the interventional group matched to the comparison group. The increasing trend in mean scores over time suggests that the intervention had a encouraging sway on the outcome being measured. The statistical significance in the pre-test phase indicates initial group differences that were addressed through the intervention, leading to improved outcomes for the interventional group across the various follow-up points. Similarly, such analysis articulates the rationale to justify the methodologies using RM ANOVA efficiency and ability to handle baseline covariates effectively in the study [24].

Table 5: Post Hoc Bonferroni test on Barthel Index among Interventional and comparison groups of stroke survivors.

Barthel Index Observations Follow up		Interventional Group				Comparison Group			
		MD	SE	F Value	P Value	MD	SE	F Value	P Value
Pre-test	Post -test at Discharge	-2.380	0.187	161.783	<0.001	-1.300	0.174	55.577	<0.001
	Post-test at 6th Week	-5.060	0.203	622.186	<0.001	-2.620	0.169	241.011	<0.001
	Post-test at 12th Week	-9.700	0.262	1368.074	<0.001	-5.600	0.223	629.770	<0.001
	Post test at 24th Week	-14.760	0.235	3950.201	<0.001	-7.720	0.262	868.730	<0.001

F value- RM ANOVA Value, P value- test of significance, SE- Standard Error, MD-Mean Difference

Table 5 depicts the Bonferroni post hoc analysis of Barthel Index (BI) scores. Statistically significant improvements were observed in both the interventional and comparison groups across all follow-up time points (*P*<0.001). Notably, the interventional group had a larger mean difference, from -2.380 at discharge to -14.760 at 24 weeks, compared to the comparison group (-1.300 to -7.720). Such configurations suggest that the intervention led to greater improvements in daily functional abilities. These outcomes corroborate existing research on the efficacy of mirror therapy in enhancing post-stroke functional independence [25, 26].

Table 6: Post Hoc Bonferroni test on RMFA among Interventional and comparison group of stroke survivor.

RMFA Observations Follow up		Interventional Group				Comparison Group			
		MD	**SE**	**F Value**	**P Value**	**MD**	**SE**	**F Value**	**P Value**
Pre-test	Post -test at Discharge	-5.900	0.577	104.451	<0.001	-5.240	0.336	242.751	<0.001
	Post-test at 6th Week	-15.840	0.678	545.583	<0.001	-12.740	0.708	323.922	<0.001
	Post-test at 12th Week	-23.760	0.781	926.327	<0.001	-16.380	0.909	324.490	<0.001
	Post test at 24th Week	-32.460	0.908	1278.944	<0.001	-20.640	1.153	320.601	<0.001

F value- RM ANOVA Value, P value- test of significance, SE- Standard Error, MD-Mean Difference

Table 6 presents the Post Hoc Bonferroni test on the RMFA, which further supports the encouraging effect of the intervention on motor function recovery among stroke patients. In the Interventional group, the mean difference in RMFA scores increased substantially at each follow-up point, starting from -5.900 at discharge to -32.460 (SE = 0.908) by the 24th week. The high F-value of 302.679 (P < 0.001) indicates a statistically significant advancement over time. Similarly, the comparison group showed improvement in motor function, but the gains were relatively modest. The final mean difference at week 24 was -20.640 (SE = 1.153), with an F-value of 84.759 (P < 0.001). These findings highlight that while both groups experienced functional motor gains, the structured intervention significantly accelerated and enhanced motor recovery in the intervention group. Repeated measures techniques are often used to estimate the efficacy of interventions and track recovery trajectories in stroke rehabilitation [27].

Table 7: Independent sample t-test on Barthel Index scores of Interventional and comparison group of stroke survivors

Independent Samples Test										
Post-test total Barthel Index Score		**Levene's Test for Equality of Variances**		**t-test for Equality of Means**						
		F	**Sig.**	**t**	**df**	**Sig. (2-tailed)**	**Mean Difference**	**SE Difference**	**95% CI of the Difference**	
									Lower	**Upper**
At Discharge	Equal variances assumed	4.265	0.042	2.433	98	0.017	-1.000	0.411	-1.816	-0.184
	Equal variances not assumed			2.433	93.195	0.017	-1.000	0.411	-1.816	-0.184
At Six Weeks	Equal variances assumed	0.810	0.370	1.058	98	0.293	0.360	0.340	-0.315	1.035
	Equal variances not assumed			1.058	96.053	0.293	0.360	0.340	-0.316	1.036
At Twelve Weeks	Equal variances assumed	0.003	0.956	7.320	98	<0.001	2.020	0.276	1.472	2.568
	Equal variances not assumed			7.320	97.418	<0.001	2.020	0.276	1.472	2.568
At Twenty-Four Weeks	Equal variances assumed	5.983	0.016	18.614	98	<0.001	4.960	0.266	4.431	5.489
	Equal variances not assumed			18.614	87.332	<0.001	4.960	0.266	4.430	5.490

df- Degree of freedom, Sig.- Significance, CI- Confidence Interval, SE- Standard Error, F- Levene's test, t- independent sample test

Table 7 illustrates the Independent Samples t-test, showing statistically significant variances between groups at different follow-up time points. At discharge, the interventional group showed significantly better outcomes (t = -2.433, P = 0.017). No significant difference was observed at 6 weeks (P = 0.293), indicating a temporary plateau. However, by 12 weeks (t = 7.320, P < 0.001) and 24 weeks (t = 18.614, P < 0.001), the interventional group demonstrated significantly higher Barthel Index scores, with mean differences of 2.02 and 4.96, respectively, indicating progressive and sustained functional improvement over time compared to the comparison group. Such results also support changing long-term functional independence among survivors with moderate and intense stroke [28].

Table 8: Independent sample t-test on Revermead Motor Function assessment for mobility motor function activities of stroke survivors

Independent Samples Test										
Post-test total Score of RMF		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
At Discharge	Equal variances assumed	43.137	<0.001	3.235	98	0.002	-5.240	1.620	-8.454	-2.026
	Equal variances not assumed			3.235	85.562	0.002	-5.240	1.620	-8.460	-2.020
At Six Weeks	Equal variances assumed	14.854	<0.001	2.324	98	0.022	-2.800	1.205	-5.191	-0.409
	Equal variances not assumed			2.324	90.206	0.022	-2.800	1.205	-5.194	-0.406
At Twelve Weeks	Equal variances assumed	14.098	<0.001	1.635	98	0.105	1.480	0.905	-0.317	3.277
	Equal variances not assumed			1.635	86.200	0.106	1.480	0.905	-0.320	3.280
At Twenty-Four Weeks	Equal variances assumed	90.567	<0.001	11.604	98	<0.001	5.920	0.510	4.908	6.932
	Equal variances not assumed			11.604	49.000	<0.001	5.920	0.510	4.895	6.945
df- Degree of freedom, Sig.- Significance, CI- Confidence Interval, SE- Standard Error, F- Levene's test, t- independent sample test										

Table 8 depicts that, at discharge, the interventional group had significantly higher RMF scores (t = -3.235, P = .002), with a mean difference of 5.24 points, indicating better motor function. This trend continued at 6 weeks (t = -2.324, P = .022), with a significant mean difference of 2.80 points. At 12 weeks, the difference was not statistically significant (P = .105), suggesting a temporary convergence in outcomes. However, by 24 weeks, a highly significant difference re-emerged (t = 11.604, P < .001), with the interventional group scoring 5.92 points higher, indicating sustained and superior functional recovery. These outcomes indicate that while early gains were seen in the interventional group, the most substantial improvements emerged at the 24-week mark, underscoring the long-term efficacy of the intervention in enhancing motor function. A recent relevant study also supports the results, demonstrating that individualized fatigue-controlled training led to superior motor function recovery in post-stroke patients [29].

Table 9: Association Between Pre-test Mean Scores of Barthel Index and Socio-demographic Variables in Interventional and Comparison Groups of Stroke Survivors.

S N	Baseline Data	Interventional Group (n=50)					Comparison (n=50)				
		n=50	BI Score		Chi-Square		n=50	BI Score		Chi-Square	
			01- 13	14-20	χ^2	Sig.		01- 13	14-20	(χ^2)	Sig.
1.	**Age**										
	41-55	15	10	05	0.485	0.785	09	00	09	1.787	0.181
	56-70	34	23	11			41	07	34		
	Above 70	01	01	00			00	00	00		
2.	**Gender**										
	Male	36	27	09	2.895	0.089	41	07	34	1.787	0.181
	Female	14	07	07			09	00	09		
3.	**Marital Status**										
	Married	38	24	14	1.706	0.192	34	04	30	0.441	0.507
	Widow/ -er	12	10	02			16	03	13		
4.	**Religion**										
	Hindu	46	31	15	0.098	0.754	41	04	36	0.616	0.432
	Muslim	04	03	01			09	02	07		
5.	**Types of Family**										
	Joint	35	23	12	0.280	0.597	26	03	23	0.273	0.602
	Nuclear	15	11	04			24	04	20		
6.	**Area of Dwelling**										
	Rural	30	19	11	0.751	0.386	28	03	25	0.571	0450
	Semi Urban	20	15	05			22	04	18		

7.	**Educational Status**										
	Illiterate	07	06	01	1.617	0.806	19	02	17	3.101	0.541
	P.M. Level	04	03	01			10	03	07		
	Secondary	19	12	07			10	01	09		
	HS School	10	06	04			07	01	06		
	≥Graduate	10	07	03			04	00	04		
8.	**Occupational Status**										
	Skilled	37	25	12	0.012	0.912	32	04	28	0.166	0.684
	Unskilled	13	09	04			18	03	15		
9.	**Total Monthly Family Income (Rs.)**										
	Less than 6000	00	00	00	3.043	0.385	01	00	01	1.867	0.760
	6001-18000	05	03	02			07	02	05		
	18001-31000	21	12	09			20	03	17		
	31001-46000	16	12	04			12	01	11		
	46001->60000	08	07	01			10	01	09		
10.	**Family Members**										
	Two and three	19	11	08	5.341	0.148	27	05	22	1.299	0.522
	Four (4)	25	17	08			19	02	17		
	≥Five (5)	06	06	00			04	00	04		
11.	**Any Insurance Facility available**										
	No other MI	28	22	06	3.268	0.071	23	02	21	0.995	0318
	GMI Scheme	22	12	10			27	05	22		
12.	**Substance Abuse**										
	Tobacco (T.)	16	13	03	3.078	0.215	16	00	16	6.049	0.109
	Alcohol (A.)	00	00	00			06	02	04		
	Both T. and A.	22	15	07			24	05	19		
	None above	12	06	06			04	00	04		

Sig. P- value- test of significance, BI- Barthel Index, HS- Higher Secondary, MI- Medical Insurance, GMI- Government Medical Insurance, T. & A.- Tobacco and Alcohol, P. &M. – Primary and Middle School level

Table 9 presents the analysis, suggesting that sociodemographic factors, including age, gender, marital status, religion, family type, dwelling area, education, occupation, income, family size, insurance status, and substance abuse, did not significantly differentiate the Interventional and comparison groups in terms of their Barthel Index scores. A study also depicted a significant improvement in BI score from discharge to 3 months post-stroke, providing insights into natural recovery trajectories and the promising impact of interventions [30]. The P-values for all comparisons were greater than 0.05, indicating that these variables did not have a statistically significant impact on the outcomes.

Table 10: Association between Pre-test mean scores of Barthel Index and clinical variables in Interventional and comparison groups of stroke survivors.

S N	Baseline Data	Interventional Group (n=50)					Comparison (n=50)				
		n=50	BI Score		Chi-Square /Sig.		n=50	BI Score		Chi-Square /Sig.	
			01- 13	14-20	χ^2	P value		01- 13	14-20	(χ^2)	P value
1.	**Types of strokes**										
	Ischemic	35	20	15	6.320	0.012	29	04	25	0.002	0.960
	Haemorrhagic	15	14	01			21	03	18		
2.	**Suffering from stroke since**										
	0-7 days	07	03	04	6.478	0.039	25	02	23	3.571	0.168
	8-14 days	29	18	11			20	03	17		
	15-30 days	14	13	01			05	02	03		
3.	**Location of any disability**										
	RUL	01	00	01	26.294	<0.001	03	00	03	10.041	0.018
	LUL	20	06	14			24	00	24		
	RUL and LL	05	05	00			05	02	03		
	LUL and LL	24	23	01			18	05	13		

4.	**Severity of stroke as per clinical assessment**										
	Mild	00	00	00	25.868	<0.001	09	00	09	1.802	0.406
	Mild Moderate	21	06	15			30	05	25		
	Severe	29	28	01			11	02	09		
5.	**Any Comorbidity**										
	HTN.	12	10	02	4.332	0.115	11	01	10	0.406	0.859
	DM.	13	06	07			14	02	12		
	HTN. and DM.	25	18	07			25	04	21		
BI- Barthel Index, P value- test of significance, RUL- Right Upper Limb, LUL- Left Upper Limb, LL- Lower Limb, HTN- Hypertension, DM- Diabetes Mellitus											

Table 10 presents the analysis of Barthel Index (BI) scores, revealing significant differences in functional outcomes within the Interventional group based on specific stroke-related factors. A statistically significant association was observed between the type of stroke and BI score (P = 0.012), with ischemic stroke patients showing comparatively better functional outcomes. Similarly, the duration since stroke onset had a notable impact on recovery (P = 0.039), where those assessed within the first week exhibited lower BI scores, indicating greater dependence in daily activities. A similar study also suggests that patients with hemorrhagic stroke had lower adjusted means BI scores matched to those with ischemic strokes, supporting the observation that stroke type influences functional recovery [30]. The location of disability significantly influenced BI scores in both groups, with bilateral and dominant side involvement correlating with poorer outcomes (P < 0.001 in the Interventional Group; P = 0.018 in the Comparison Group). Stroke severity also emerged as a critical determinant, with severe strokes significantly associated with lower BI scores in the Interventional Group (P < 0.001), a trend not mirrored in the comparison group. Although comorbidities such as hypertension and diabetes did not show statistically significant associations in either group, a trend toward poorer outcomes with multiple comorbidities was noted. Overall, the findings suggest that targeted interventions may contribute to improved functional independence post-stroke, particularly when initiated early and in patients with less severe impairments.

Table 11: Association between Pre-test mean scores of RMFA and selected clinical variables in Interventional and comparison groups of stroke survivors.

S N	Baseline Data	Interventional Group (n=50)					Comparison (n=50)				
		n=50	RMFA Score		Chi-Square /Sig.		n=50	RMFA Score		Chi-Square /Sig.	
			01- 40	41-70	χ^2	P value		01- 40	41-70	(χ^2)	P value
1.	**Types of strokes**										
	Ischemic	35	14	21	15.517	< 0.001	29	13	16	0.038	0.845
	Haemorrhagic	15	15	00			21	10	11		
2.	**Suffering from a stroke since**										
	0-7 days	07	01	06	16.755	< 0.001	25	14	11	2.053	0.358
	8-14 days	29	14	15			20	07	13		
	15-30 days	14	14	00			05	02	03		
3.	**Location of any disability**										
	RUL	01	00	01	28.756	0.000	03	00	03	50.000	< 0.001
	LUL	20	03	17			24	00	24		
	RUL and LL	05	05	00			05	05	00		
	LUL and LL	24	21	03			18	18	00		
4.	**Severity of stroke as per clinical assessment**										
	Mild	00	00	00	28.403	<0.001	09	04	05	4.224	0.121
	Mild Moderate	21	03	18			30	11	19		
	Severe	29	26	03			11	08	03		
5.	**Any Comorbidity**										
	HTN.	12	10	02	7.160	0.028	11	04	07	0.829	0.661
	DM.	13	04	09			14	06	08		
	HTN. and DM.	25	15	10			25	13	12		
RMFA- Rivermead Motor Function Assessment, P value- test of significance, RUL- Right Upper Limb, LUL- Left Upper Limb, LL- Lower Limb, HTN- Hypertension, DM- Diabetes Mellitus											

Table 11 depicting the analysis of Rivermead Motor Function Assessment (RMFA) scores further emphasized the positive influence of early intervention on motor regaining in stroke survivors. A significant association was found between stroke type and motor function in the interventional group (P < 0.001), with ischemic stroke patients achieving higher RMFA scores than those with hemorrhagic strokes. The timing of assessment post-stroke was also critical, as earlier intervention (within 0–7 days) correlated with better motor outcomes (P<0.001). The location of the disability had a pronounced impact in both groups (P<0.001), with localized impairments—particularly those affecting a single limb—linked to higher motor function scores. A longitudinal study highlighted that comparing functional and motor outcomes at various time points post-stroke found significant improvement within the first two months, with a plateau observed thereafter, which also aligns with the observed pattern in the current data, where early gains are followed by a stabilization period [31]. Stroke severity demonstrated a significant relationship with motor outcomes in the Interventional Group (P < 0.001), where milder strokes were associated with better recovery. Additionally, comorbidities such as hypertension showed a significant association with RMFA scores in the Interventional Group (P = 0.028), indicating that underlying health conditions may affect motor function rehabilitation. In contrast, these associations were largely absent in the comparison group, highlighting the promising benefits of structured interventions in enhancing motor recovery after stroke.

Table 12: Association between Pre-test mean scores of RMFA and selected socio-demographic variables in Interventional and Comparison groups of stroke survivors.

S N	Baseline Data	Interventional Group (n=50)					Comparison (n=50)				
		n=50	RMFA Score		Chi-Square/ Sig.		n=50	RMFA Score		Chi-Square/ Sig.	
			01- 40	41-70	χ^2	p		01- 40	41-70	(χ^2)	p
1.	Age										
	41-55	15	09	06	0.811	0.667	09	06	03	1.887	0.170
	56-70	34	19	15			41	17	24		
	Above 70	01	01	00			00	00	00		
2.	Gender										
	Male	36	22	14	0.511	0.475	41	21	20	2.498	0.114
	Female	14	07	07			09	02	07		
3.	Marital Status										
	Married	38	22	16	0.001	0.979	34	14	20	0.995	0.318
	Widow/-er	12	07	05			16	09	07		
4.	Religion										
	Hindu	46	27	19	0.114	0.735	41	20	21	0.709	0.400
	Muslim	04	02	02			09	03	06		
5.	Types of Family										
	Joint	35	19	16	0.661	0.416	26	12	14	0.001	0.982
	Nuclear	15	10	05			24	11	13		
6.	Area of Dwelling										
	Rural	30	17	13	0.055	0.815	28	11	17	1.155	0.283
	Semi Urban	20	12	08			22	12	10		
7.	Educational Status										
	Illiterate	07	04	03	1.966	0.742	19	09	10	1.830	0.767
	P.M. Level	04	03	01			10	06	04		
	Secondary	19	09	10			10	04	06		
	HS School	10	07	03			07	02	05		
	≥Graduate	10	06	04			04	02	02		
8.	Occupational Status										
	Skilled	37	24	13	2.753	0.097	32	12	20	2.585	0.108
	Unskilled	13	05	08			18	11	07		

9.	**Total Monthly Family Income (Rs.)**										
	Less than 6000	00	00	00	3.302	0.347	01	00	01	2.918	0.572
	6001-18000	05	02	03			07	05	02		
	18001-31000	21	10	11			20	09	11		
	31001-46000	16	11	05			12	05	07		
	46001->60000	08	06	02			10	04	06		
10.	**Family Members**										
	Two and three	19	09	10	2.408	0.498	27	13	14	2.046	0.809
	Four (4)	25	16	09			19	07	12		
	≥Five (5)	06	04	02			04	03	01		
11.	**Any Insurance Facility available**										
	No other MI	28	18	10	1.032	0.310	23	09	14	0.809	0.368
	GMI Scheme	22	11	11			27	14	13		
12.	**Substance Abuse**										
	Tobacco (T.)	16	11	05	2.084	0.353	16	06	10	5.549	0.136
	Alcohol (A.)	00	00	00			06	04	02		
	Both T. and A.	22	13	09			24	13	11		
	None above	12	05	07			04	00	04		

Sig. P- value- test of significance, RMFA-Rivermead Motor Function Assessment, HS- Higher Secondary, MI- Medical Insurance, GMI- Government Medical Insurance, T. & A.- Tobacco and Alcohol, P. &M. – Primary and Middle School level

Table 12 presents the analyses of the given data, where Most variables demonstrated no statistically significant differences among groups, indicating comparable baseline distributions. The age distribution was similar (P = 0.667 for the interventional group; P = 0.170 for the comparison), with the 56–70 age group being the most represented. Gender, marital status, religion, family type, and area of residence also showed no significant differences (all P > 0.1), ensuring baseline homogeneity. Educational and occupational status were evenly distributed across both groups, with skilled workers being the predominant group. Monthly family income and family size did not vary significantly between groups (P > 0.3), and insurance facility availability was relatively balanced (P = 0.310 for the intervention; P = 0.368 for comparison). Regarding substance abuse, a higher number of participants in both groups reported use of both tobacco and alcohol; however, the changes were not statistically significant (P=0.353 for interventional; P=0.136 for comparison). Given the comparable baseline characteristics across group as shown in above table, the improvements observed at 24 weeks in the intervention group were likely attributable to the rehabilitation intervention. This is further supported by earlier research, which indicated that artificial intelligence into rehabilitation can predict and enhance long-term motor recovery, consistent with the outcomes seen in the study[32].

DISCUSSION

The study aimed to explore the impact of mirror therapy on improving mobility, motor function recovery, and functional independence in stroke survivors through a randomized controlled trial. The ultimate focus was on evaluating how mirror therapy affects neuroplasticity, functional recovery, and the relationship between mobility, motor function, and functional independence in daily living activities. The research question for this randomized controlled trial was: "How does the impact of Mirror Therapy compare to standard rehabilitation in recovering motor function and functional independence?"

The discussion section delved into the findings and implications of the study, highlighting the possible benefits and outcomes of incorporating mirror therapy into rehabilitation protocols. The study on the impact of mirror therapy interventions for stroke survivors presents significant findings regarding the enhancement of motor function and daily living activities. This research study has followed the CONSORT (Consolidated Standards of Reporting Trials) guidelines.

Demographic and socio-economic similarities at baseline between the interventional and comparison groups were comparable in terms of age, gender, marital status, religion, family type, dwelling area, education, occupation, income, family size, insurance status, and substance use.

Baseline differences in the interventional group included higher education levels, more skilled workers, higher income, and longer stroke duration with more severe strokes. The comparison group had higher illiteracy rates and milder strokes occurring earlier post-onset.

Significantly higher scores demonstrated the impact of mirror therapy on outcomes in the interventional group over time, as measured by functional assessments (Barthel

Index) and motor assessments (RMFA). Repeated-measures ANOVA revealed greater improvements in the interventional group, with large effect sizes. Post hoc analyses confirmed the superiority of the intervention in improving motor and functional outcomes.

Association with stroke characteristics for better outcomes was linked to ischemic strokes, shorter duration since stroke onset, unilateral, and less severe strokes. Severe strokes, bilateral involvement, and dominant side disability were associated with poorer recovery. Early intervention (within 0–7 days) was associated with improved motor and functional outcomes. Comorbidities such as hypertension influenced motor recovery, especially in the interventional group.

No Significant impact of socio-demographic variables, such as age, gender, socioeconomic status, and substance use, was found, indicating the intervention's effectiveness across diverse demographics.

The burden of non-communicable diseases, particularly stroke, necessitates a comprehensive approach involving prevention and post-stroke rehabilitation. A study emphasized the role of education in promoting awareness about risk factors like tobacco and alcohol among adolescents to prevent strokes. Integrating health education at a young age can lead to the development of lifelong healthy habits. This highlights the importance of a public health strategy that integrates preventive education with effective post-stroke rehabilitation for comprehensive care [33].

The study found a significant statistical difference ($P<0.001$) in motor recovery, spasticity, and extremity functionality between the standard rehabilitation and mirror therapy groups. Mirror therapy showed marked improvement compared to standard therapy for chronic stroke patients, suggesting its potential in aiding neurological recovery within two weeks. The study highlights the effectiveness of mirror therapy in promoting motor recovery, reducing spasticity, and enhancing hand function. These results highlight mirror therapy as a promising intervention for individuals with chronic stroke, showcasing efficient and notable improvements in neurological recovery and functional outcomes within a short two-week timeframe [34].

The study confirms that both intervention and comparison groups were demographically comparable at baseline, supporting internal validity. Similar findings were reported in a previous study, which emphasized the importance of baseline homogeneity in stroke rehabilitation trials to ensure valid comparisons [19]. Additionally, a research study highlighted that those socioeconomic factors, when balanced, do not confound rehabilitation outcomes, reinforcing the current study's approach [35].

The study demonstrates significant improvements in functional (Barthel Index) and motor (RMFA) scores with structured intervention, consistent with former research. Former research found that early, task-specific, and intensive rehabilitation significantly enhances motor recovery post-stroke [36]. Similarly, yet another research study reported that structured rehabilitation accelerates functional independence, especially when initiated early [37].

Findings indicate that ischemic strokes, shorter duration since onset, unilateral, and less severe strokes relate to reliable recovery, aligning with existing literature. Similarly, a research study emphasized that stroke severity and lesion location are critical prognostic factors influencing rehabilitation outcomes [38]. Moreover, a previous study highlighted that early intervention in less severe strokes yields superior functional gains [37].

The study reports no significant influence of sociodemographic variables on rehabilitation outcomes, consistent with recent meta-analyses. A research study also concluded that when high-quality, structured rehabilitation is provided, demographic factors have minimal impact on recovery trajectories [38]. This underscores the importance of tailored, intensive therapy over demographic considerations alone.

The association of stroke type, location, severity, and timing with outcomes aligns with prior research. Similarly, a study emphasized that early intervention, especially in ischemic and less severe strokes, significantly improves functional and motor recovery [20]. Additionally, A study also highlighted that bilateral and dominant side involvement predict poorer outcomes, reinforcing current findings [37].

The study demonstrates that structured interventions significantly enhance motor recovery and functional independence in stroke patients, aligning with recent research that emphasizes the importance of targeted rehabilitation programs [39, 40]. The observed improvements in BI and RMFA scores over time underscore the efficacy of such interventions, consistent with recent research findings that report early, structured motor training accelerates functional gains post-stroke [41].

Furthermore, the differential correlation patterns between the groups suggest that while both groups improve, the relationship between motor function and daily activities becomes more robust in the comparison group over time, possibly due to natural recovery processes or less structured rehabilitation. This aligns with recent studies indicating that individualized, intensive rehabilitation can optimize motor and functional outcomes [42].

Lastly, the findings support the notion that comprehensive stroke rehabilitation should incorporate both motor and functional assessments to tailor interventions effectively, as highlighted by recent systematic reviews emphasizing personalized therapy approaches [43].

Limitations of the Study

This was a single-centre study conducted exclusively at Patna Medical College Hospital, Patna, due to administrative and governmental constraints. To mitigate the risk of dropouts resulting from other health issues, a sample size of 100 was selected. The individual responsible for data analysis was kept blinded throughout the study.

Implications of the study

The implications of this research are multifaceted. Firstly, the positive outcomes support the integration of Mirror Therapy into standard rehabilitation protocols for stroke survivors, particularly in settings where traditional therapies may be limited. The findings underscore the critical importance of early, structured rehabilitation in optimizing stroke recovery outcomes across diverse patient populations. The demonstrated effectiveness of intervention within the first week post-stroke focuses the need for healthcare systems to prioritize prompt initiation of therapy, which can significantly enhance motor and functional independence. Additionally, the study confirms that stroke severity, type, and timing are key prognostic factors, guiding clinicians to tailor rehabilitation strategies accordingly. Importantly, the lack of significant influence from sociodemographic variables suggests that such interventions can be universally effective, promoting equitable access to stroke rehabilitation regardless of socioeconomic status or demographic background. These insights advocate for integrating early rehabilitation protocols into standard stroke care pathways and emphasize the necessity for healthcare policies that facilitate timely access to comprehensive therapy services. Ultimately, implementing these strategies can lead to improved quality of life, reduced caregiver burden, and decreased long-term healthcare costs associated with stroke disability.

CONCLUSION

This comprehensive study underscores the promising role of mirror therapy as an adjunct to standard stroke rehabilitation protocols. The findings demonstrate that structured interventions incorporating mirror therapy, coupled with regular follow-up support, significantly enhance motor recovery and functional independence among stroke survivors. The intervention group exhibited superior improvements in activities of daily living, as measured by the Barthel Index, and motor function, assessed via the Rivermead Motor Assessment, across all follow-up points compared to the control group. These results emphasise the potential of mirror therapy to accelerate recovery trajectories, enabling patients to regain independence more rapidly and effectively.

Importantly, the study also highlights that early intervention and tailored therapeutic approaches are crucial factors in achieving successful outcomes. Factors such as stroke type, severity, and location significantly influenced recovery, with ischemic strokes, milder severity, and unilateral limb involvement associated with better functional gains. The minimal impact of sociodemographic variables suggests that the benefits of mirror therapy are broadly applicable across diverse patient populations, making it a versatile addition to stroke rehabilitation programs.

While the improvements observed in the intervention group are encouraging, it is noteworthy that some measures did not reach statistical significance, indicating the necessity for additional research to confirm and optimize these benefits. The correlation between motor gains and functional independence reinforces the importance of integrating motor-focused therapies early in the rehabilitation process. Additionally, the study's findings support the importance of incorporating regular follow-up support, which appears to sustain and enhance recovery gains over time.

Future Recommendations

Building on these findings, future research should focus on larger, multicenter randomized controlled trials to validate the efficacy of mirror therapy across different settings and populations. Long-term studies are essential to assess the durability of functional gains and to determine whether continued or booster sessions of mirror therapy can sustain improvements over extended periods. Cost-effectiveness analyses are also warranted to evaluate the practicality of widespread implementation, especially in resource-constrained environments.

Moreover, exploring the incorporation of mirror therapy with other neurorehabilitation modalities, such as robotic-assisted therapy or virtual reality, could potentially amplify recovery outcomes. Personalized therapy protocols, tailored to individual stroke characteristics and patient preferences, may further optimize results. Investigating the neurophysiological mechanisms underlying mirror therapy's effects through neuroimaging studies could provide deeper insights into its therapeutic potential.

In conclusion, mirror therapy emerges as a valuable, non-invasive, and cost-effective intervention that can significantly contribute to stroke rehabilitation. Its incorporation into standard care, particularly when initiated early and supported by regular follow-up, holds rewarding for improving the quality of life for stroke survivors. Continued research and innovation are crucial for refining these approaches and establishing evidence-based guidelines for widespread clinical adoption.

OTHER INFORMATION

ETHICAL APPROVAL

Institutional Ethical Committee, Patna Medical College, Patna, Approval Letter No. EC/15, dated 02.06.2022).

Clinical Trials Registry of India, New Delhi (CTRI) under the number CTRI/2023/07/054998, dated 10.07.2023. Written consent was obtained from all participants prior to data collection in the study.

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CONFLICT OF INTEREST

The authors announce no conflict of interest related to this study.

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