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Effects of Brunnstrom movement therapy versus mirror therapy on hand function in post-stroke hemiplegic population

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ABSTRACT

Objectives: The objective of this study was to compare the effects of Brunnstrom movement therapy and mirror therapy (MT) on hand function in the post-stroke hemiplegic population.

Methods: This randomized control pilot trial was conducted at District Headquarters Hospital and Rafiqa Hospital Sargodah, Pakistan in 2022. A total of 26 stroke patients having spastic hands aged 40–70 were randomized into two groups. Group A was treated with Brunnstrom movement therapy along with conventional treatment. Group B was treated with MT and conventional treatment. Fugl-Meyer assessment: wrist and hand subtest (items VII, VIII, and IX) and Brunnstrom hand manipulation were used to assess outcome measures.

Results: Twenty-six patients of both sexes, 13 in each group. The mean age in Group A was 58.30 ± 7.53, and Group B's was 57.46 ± 8.40. Brunnstrom movement and MT scores showed a statistically significant difference within a group ($P < 0.05$). The between-group comparison showed a statistically significant difference ($P < 0.05$). Between-group comparison of results showed marked improvement in Fugl-Meyer in the case of Brunnstrom movement therapy compared to MT.

Conclusion: This study concluded that stroke patients treated with Brunnstrom movement therapy showed more improvement in hand functioning and activities of daily living than those treated with MT.

Keywords: Brunnstrom, Fugl-Myer assessment, Hand recovery stages, Hemiplegia, Mirror therapy, Movement therapy, Stroke

INTRODUCTION

Stroke is a considerable root of affliction worldwide. The World Health Organization defines stroke as a "Clinical sign that occurs rapidly resulting into focal (or global) disturbance of cerebral function." The evaluated annual incidence of stroke in Pakistan is estimated at 250/100,000. There are no extended epidemiological studies at hand to rule out the true extent of stroke in the region

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of Pakistan.[1] According to a worldwide health survey, stroke is rated as the second leading cause of death, with a yearly 5.5 million mortality rate.[2]

In plain words, a stroke is a neurological disorder that occurs when a blockage of blood vessels impedes blood circulation to the brain and clogs arteries, causing the occlusion of blood supply to focal areas of the brain.[3,4] In most cases, 50–70% of patients get motor disabilities that entail upper extremity impairments, which hinder voluntary and well-coordinated movements in everyday tasks.[5] To regain lost movement coordination, muscle strength, and the potential to do activities of daily living (ADL), up-to-date rehabilitation maneuvers have to be established.[6] Due to population aging, continuing high prevalence of risks (e.g., diabetes and hypertension), and inadequate management, the burden is expected to increase.[5]

One of the most important stroke-associated signs and symptoms of motor deficits is represented by weakness (hemiparesis) or paralysis (hemiplegia) contralateral to the side of the lesion.[7] It causes long-term disability that affects ADL, and cognition and function are experienced by survivors. Speech dysfunction like aphasia may happen.[8] Additional signs include dysarthria, stupor, and optic chiasm defects.[9] Pain in the form of a severe headache is common in hemorrhagic stroke patients.[10]

Post-stroke hemiplegia is an important motor sign. Approximately 60% of the patients, after a stroke, feel upper limb dysfunction, mainly the distal limb. Spasticity is the major contributory factor mostly seen in stroke patients, mainly affecting the upper extremity regions such as shoulder, elbow, wrist, and finger flexors, resulting in decreased range of motion (ROM). The limited ROM causes secondary disabilities, which interfere with ADLs regarding the function of reach, grasp, and release.[11]

Stroke patients mostly have hand sensory impairments, mainly in proprioceptive discrimination and tactile sensation, and the impairment hinders proper hand function or manual exploration and manipulation of the environment. It is challenging for stroke survivors to achieve a proper pattern of muscle activation for functional task performance.[12] Despite intensive therapy, recovery usually plateaus, mostly impaired hand functioning more than other body parts.[13] Innumerable conventional approaches are used to treat hemiplegic hands, and some are contemporary approaches such as Brunnstrom movement therapy[14] and mirror therapy (MT),[15] constrained induced movement therapy,[16] and virtual reality.[17]

Brunnstrom movement therapy used for hand functioning is called Brunnstrom hand manipulation (BHM). It uses reflexes and muscle synergy links and develops voluntary control of hand and finger movements through sensory stimulation to eliminate spasticity and preserve movements, attaining a normal movement pattern for successful recovery.

In 1996, Ramachandran and Rogers-Ramachandran introduced MT. MT is used as an alternative in stroke patients due to its simplicity and low cost. In this technique, the patient feels the imaginary movement of the disabled side through a mirror. The mirror image created by the normal bodyside helps to integrate proprioception and visual feedback and reorganize the movement pattern.[18]

The purpose of the present study was to inform the healthcare professionals regarding advanced treatment protocols and develop strategies such as MT and Brunnstrom movement therapy for improving hand functioning of the spastic hand by decreasing spasticity after stroke. This creates awareness among the population of Pakistan regarding the best treatment strategy for performing normal hand movements and ADLs. This study opens a new window for students to explore more strategies to search in this area of research.

MATERIALS AND METHODS

This randomized clinical pilot trial had trial register reference # NCT05392543. The study was conducted at District Headquarters Hospital and Rafiqa Hospital Sargodha, Pakistan, with 10 months duration. The sample size was 26, calculated using the Epitool method, taking Fugl-Meyer as a variable.[18] The method of non-probability consecutive sampling was utilized to recruit the subjects for the study. The sample size was selected based on inclusion criteria, which included both sexes between the ages of 40 and 70. Participants with any type of stroke (ischemic or hemorrhage) were asked to take part. Stroke survivors with upper extremity and hand impairment were taken.[19] Stroke survivors, Stage 3 on the Brunnstrom improvement scale of the hand, were qualified to participate.[20]

Exclusion criteria included patients unable to follow commands. Stroke survivors with an inability to sit for more than 2 h (self-reported). Patients who underwent chemodenervation or Botox injections during the previous six months were ineligible.

The data collection tools include the Fugl-Meyer assessment (FMA). FMA is a performance-based impairment index specifically for stroke. Clinically and in research, it was applied to determine disease severity, describe motor recovery, and plan to assess treatment. The scale includes a total of five domains and 155 items. Five domains are motor performance (in the upper and lower extremities), sensory performance evaluation (evaluates light touch on two surfaces of the arm and leg, and position sense for eight joints), balance (contains seven tests, three seated, and four standing), joint ROM (eight joints), and joint pain.

The participants were divided into two groups. Group A studied with Brunnstrom movement therapy accompanied by conventional treatment protocol (hot-pack for 10 min) for four weeks on alternate days, 12 sessions for every subject, whereas Group B was treated with MT along with conventional treatment protocol (hot-pack for 10 min) for four weeks on alternate days approximately 12 sessions for every subject by lottery method.

The comprehensive BHM is applied on hand. Reflexive, synergistic, passive, and active movements were used consecutively to augment hand recovery. In MT, the mirror was placed in front of the patient in a way that it comes in midline so that the mirror covered the affected limb fully and the unaffected limb reflection was fully visible. The affected limb was positioned in a safe and secure position behind the mirror. The affected limb should be in the same position as the unaffected limb. In this way, the power of mirror illusion intensifies and enhances clarity. In the MT group, therapy emphasized reaching, holding, and dexterity. The patients were required to perform four distinct activities: (a) wrist flexion and extension, (b) forearm pronation and supination, (c) numbering and opposition, and (d) finger flexion and extension. For task-oriented goals, patients were requested to perform ADL movements (grabbing and releasing balls, using a spray bottle, kneading putty, pinching coins, using a spoon, and wiping a towel table). Each movement pattern was done 10 times and three days a week to exercise the unaffected side during these exercises.[21] Subject allocation is shown in the consolidated standards of reporting trails (CONSORT) diagram of Figure 1.

Static analysis

The Windows software, Statistical Package for the Social Sciences version 20, was used to analyze the data. Statistical $P = 0.05$ was significant. A normality test was applied to data by the Shapiro-Wilk test, which resulted in $P < 0.05$, suggesting that the data was not in a normal distribution. For between-group comparisons, the Mann–Whitney U-test was used. The Wilcoxon signed-rank test (non-parametric) was used to see variation within the group.

RESULTS

Demographic data

The mean (standard deviation) of age, body mass index (BMI), and days after stroke are shown in Table 1. In a sample of 26 participants, the BMI was 3.8% underweight, 42.3% normal, 38.5% overweight, and 15.4% obese.

Within-group analysis

Within the group (non-parametric), the Wilcoxon signed-ranks test interventional group (Brunnstrom movement therapy) showed that *P*-value of Fugl-Myer wrist, Fugl-Myer hand, Fugl-

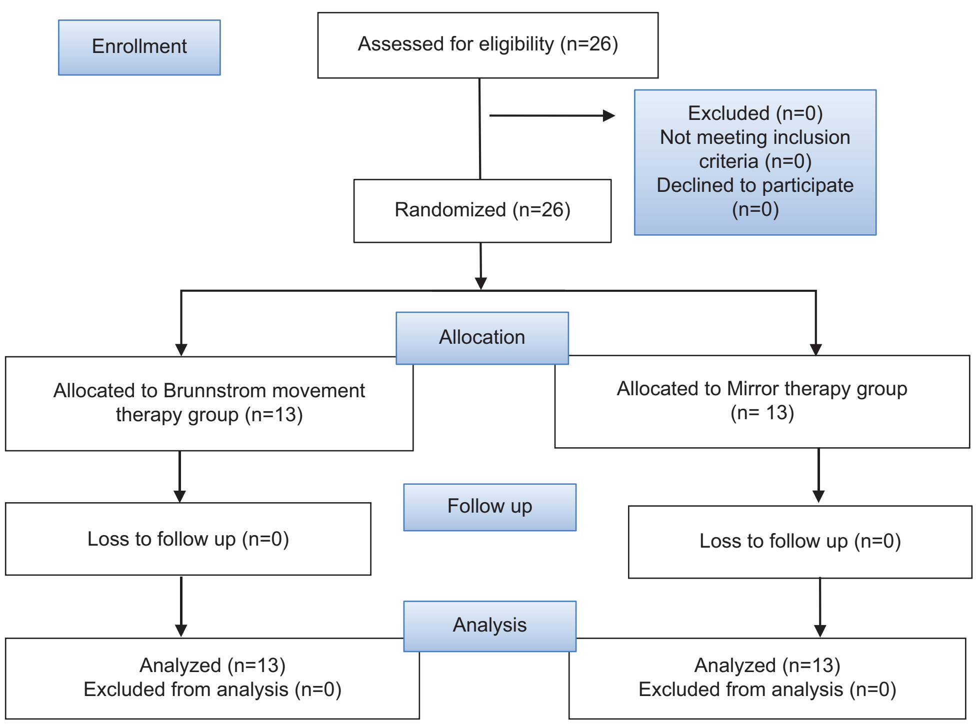

Figure 1: Consolidated standards of reporting trails (CONSORT) flow diagram. n: Total number of participants.

Myer coordination, and speed and Brunnstrom hand recovery was <0.05. Wilcoxon signed-ranks test for the control group (MT) showed that *P*-value of Fugl-Myer wrist, Fugl-Myer hand, Fugl-Myer coordination, and speed and Brunnstrom hand recovery was <0.05. This is illustrated in Table 2.

Table 1: Demographics data.

Variables	Group A	Group B
	Mean (SD)	Mean (SD)
Age (years)	58.30±7.53	57.46±8.40
BMI	41.31±61.89	25.66±4.42
Days after stroke	6.00±3.29	7.38±2.36

BMI: Body mass index, SD: Standard deviation

Table 2: Within the group comparison (Wilcoxon signed-ranks test).

Variables	*P*-value	Z-value
Group A (Interventional group)		
Fugl-Myer wrist	<0.002	3.304
Fugl-Myer hand	<0.002	3.190
Fugl-Myer coordination and speed	<0.002	3.23
Brunnstrom hand recovery	<0.002	3.314
Group B (control group)		
Fugl-Myer wrist	<0.002	3.204
Fugl-Myer hand	<0.002	3.192
Fugl-Myer coordination and speed	<0.004	3.022
Brunnstrom hand recovery	<0.002	3.314

The non-parametric Mann–Whitney test results for between-groups analysis at baseline are shown in Table 3.

The non-parametric Mann–Whitney test result between groups after the end of all sessions is shown in Table 4.

DISCUSSION

The within-group comparison showed that *P*-value of FMA was 0.00 ($P < 0.005$) in both the interventional and control groups. That means that a significant difference was present in both groups. Between-group comparison of Fugl-Myer showed that *P*-value of FMA was <0.005. There was a significant difference between the groups. Both methods showed marked improvement in FMA.

The present study's results follow Pan *et al.*'s study on stroke patients with upper limb impairment, which assessed their motor function and applied different reaching activities along with Brunnstrom movement therapy. The FMA showed significant results as $P < 0.05$. Both methods showed significant recovery in Brunnstrom's stages of recovery. A major contribution to recovery was Brunnstrom movement therapy, which improves muscle synergy in the hand as well as the upper limb and decreases spasticity, which helps in gaining functional movements.[22]

Effects of home-based unimanual and bimanual MT in patients with moderate and severe impairments of the upper extremity and hand functioning after stroke were investigated by Geller *et al.* in 2022. Improvement was measured on the

Table 3: Between the groups Mann–Whitney test (comparison on baseline values).

Variables	Groups	N	Mean rank	Z-value	*P*-value	R-value
Pre-Fugl-Myer wrist	Group A	13	14.62	0.765	0.477	0.212
	Group B	13	12.38			
Pre-Fugl-Myer hand	Group A	13	13.73	0.155	0.876	0.042
	Group B	13	13.27			
Pre-Fugl-Myer coordination and speed	Group A	13	13.27	0.158	0.875	0.043
	Group B	13	13.73			
Pre-Brunnstrom hand recovery	Group A	13	13.50	0.00	1.000	0.00
	Group B	13	13.50			

Table 4: Mann–Whitney test Between the groups' comparison on the end value.

Variables	Groups	No	Mean rank	Z-value	*P*-value	R-value
Post-Fugl-Myer wrist	Group A	13	17.54	2.831	0.005	0.785
	Group B	13	9.46			
Post-Fugl-Myer hand	Group A	13	18.96	3.699	0.000	1.025
	Group B	13	8.04			
Post-Fugl-Myer coordination and speed	Group A	13	18.54	3.522	0.000	0.976
	Group B	13	8.46			
Post-Brunnstrom hand recovery	Group A	13	18.92	3.861	0.000	1.070
	Group B	13	8.08			

FMA scale and stroke impact scale (SIS). All groups showed significant results on all outcome measures. $P < 0.05$. The results showed there were no between-group differences, which showed the effectiveness of unimanual MT on hand function. This study creates evidence for the effectiveness of present study results that showed the significant result of MT on hemiplegic hands.[23]

Rehabilitation of stroke patients with upper extremities and hand impairment by virtual reality was studied by Afsar *et al.* Participants received BMT sessions and virtual reality. Before and after results measure Brunnstrom's recovery stages, and the FMA scale and functional independence measure the self-care score. The result showed a significant value of $P < 0.05$. BMT breaks abnormal synergy patterns and spasticity, which helps achieve movement with the help of virtual reality. Hence, this study showed a strong correlation with the effectiveness of BMT.[24]

The present study followed the result of a study by Mathieson *et al*., who examined MT effectiveness in combination with functional stimulation for upper extremities, wrist, and hand motor recovery. Results showed that the interventional group improved significantly ($P = 0.03$) and the control group showed significant results, indicating that MT combined with other interventions has more effects than MT alone. Current research also studies MT effects and shows less significant results. This evidence supports the idea that MT alone has less significant results than its combined effects with another intervention, so additional studies are required to study the combined outcome of MT.[25]

Limitations

Some factors that may have affected sensory assessment, such as cognitive deficits, aphasia, and mood, were not assessed; therefore, the effect of these on sensory impairment and recovery could not be evaluated. There was insufficient data related to the frequency and duration of treatment. Both groups have large differences in BMI, which may have caused some biases in results. Another limitation was that the effects on long-term functional development could not be evaluated as patients were only followed 12 sessions in four weeks. Finally, the number of patients was small because this was a single-centered study.

CONCLUSION

The study concluded that hemiplegic hand function in chronic stroke patients improved using Brunnstrom movement therapy (Brunnstrom hand mobilization technique) and MT. Both therapies were effective and showed reliable results, but the present study showed that Brunnstrom movement therapy had superior effects on improving hand functions.

RECOMMENDATIONS

Future research may investigate stroke patients with apraxia or neglect. More mobilization techniques can be added to the study to see their effect or combined with other interventions to see their combined effects. Clinicians are recommended to enable the usage of BSMT and arrange different seminars and workshops regarding applying the techniques mentioned above. Students are recommended to attend workshops related to BSMT and MT.

AUTHORS' CONTRIBUTIONS

N, AZ and AS contributed to the conception, study design, and data collection. HS and WZ contributed to data analysis and interpretation, and LN and MG contributed to article drafting and proofreading. All authors have critically reviewed and approved the final draft and are responsible for the manuscript's content and similarity index.

ETHICAL APPROVAL

The study received approval from the Institutional Review Board of "Riphah International University" on December 6, 2022, with registration number "S21C14G37034."

DECLARATION OF PARTICIPANT CONSENT

The authors certify that they have obtained all appropriate participant consent forms. In the form, the participants have given their consent for their images and other clinical information to be reported in the journal. The participants understand that their names and initials will not be published, and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY FOR MANUSCRIPT PREPARATION

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

CONFLICTS OF INTEREST

There are no conflicting relationships or activities.

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