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Original Article

Effects of Action Observation Exercises with Complex Tasks on Upper Limb Function in Acute Stroke

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ABSTRACT

Background: Stroke is a leading cause of disability worldwide, necessitating effective rehabilitation strategies. Action observation therapy, a novel approach in stroke rehabilitation, focuses on improving motor function and functional recovery by leveraging the activation of mirror neurons through the observation and subsequent replication of actions.

Objective: The study aimed to compare the effects of action observation therapy with conventional therapy on motor function, manual dexterity, and functional recovery in patients with acute stroke.

Methods: This randomized control trial enrolled 58 acute stroke patients, divided equally into an experimental group (action observation therapy) and a control group (conventional therapy). Participants, aged 40-75 years, were selected using non-probability purposive sampling and randomized via a coin toss method. The study was conducted at Rafsan Neuro Rehab Center, Peshawar, over six months. Inclusion criteria included acute stroke phase, MMSE >24, and Fugl-Meyer Assessment score ≥20. Exclusion criteria were posterior circulation infarction, multiple strokes, and cognitive impairments. Outcome measures included the Fugl-Meyer Assessment scale, Box and Block test, and the REACH scale. Data were analyzed using SPSS v25, employing parametric and non-parametric tests as appropriate.

Results: The experimental group showed a significant improvement in motor functions and functional recovery, with post-treatment Fugl-Meyer scores increasing from 29.69 ± 5.04 to 57.31 ± 4.01 (p = 0.001). The control group also exhibited improvement, with scores rising from 27.00 ± 4.71 to 54.24 ± 5.14 (p = 0.001). However, improvements in manual dexterity, as measured by the Box and Block test, were not statistically significant.

Conclusion: Action observation therapy significantly enhances motor functions and functional recovery in acute stroke patients compared to conventional therapy, although its impact on manual dexterity requires further investigation. These findings suggest that incorporating action observation into stroke rehabilitation protocols could be beneficial.

Keywords: Action Observation Therapy, Stroke Rehabilitation, Motor Function, Functional Recovery, Acute Stroke, Manual Dexterity.

INTRODUCTION

Stroke, a leading medical concern worldwide, is the second primary cause of mortality and a significant contributor to disability, especially in the elderly population (1). The incidence of stroke has alarmingly escalated in middle and low-income countries, more than doubling in the past four decades (2). This trend is particularly pronounced in low-income nations, where there has been an average annual increase in stroke prevalence of 14.3% (3). Notably, about 88% of stroke survivors return home, yet many remain permanently disabled. The global impact of stroke is considerable, accounting for approximately 5.5 million deaths annually, with South Asia contributing to nearly 20% of these figures (4). In the United States, the economic burden of stroke is substantial, with estimated direct and indirect costs of $45.5 billion (5). Pakistan, for instance, has a stroke incidence of 250 per 100,000 people, resulting in 350,000 new cases each year (6).

Stroke's risk factors are predominantly hypertension, alcoholism, abdominal obesity, poor diet, and lack of physical activity, collectively accounting for over 80% of global stroke risk (7). Post-stroke conditions frequently include hemiparesis, hemianesthesia,

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speech impairments, and perceptual and balance issues (8). Traditional stroke rehabilitation methods have shown limited efficacy in restoring hand mobility and motor skills, leading to complications like spasticity if effective rehabilitation is not undertaken (9, 10).

Rehabilitative interventions are crucial for regaining independence and enhancing functional recovery. Enhanced exercise rehabilitation, particularly within the first six months post-stroke, has been effective in improving activities of daily living (ADL), instrumental ADL, and gait (12). Recent advancements in rehabilitation approaches for hand dexterity recovery post-stroke include task-oriented therapy, motor relearning programs, robot-assisted rehabilitation, and virtual reality, alongside traditional methods such as proprioceptive neuromuscular facilitation, the Brunnstrom approach, Rood's approach, the Bobath approach, constraint-induced movement therapy, and range of motion exercises (13-20).

Task-oriented therapy emphasizes engaging in real-life activities for skill learning or relearning, necessitating challenging, adaptable tasks with active patient involvement (21). The motor relearning program, based on biomechanics, sports science, neuroscience, and cognitive psychology, aims to restore motor control through scientific motor and learning processes (22). Rehabilitation robotics and virtual reality are innovative approaches that enhance motor skill recovery and patient engagement in rehabilitation (18, 23, 24).

Action observation training, a new technique targeting motor learning through mirror neurons activation, shows promise in enhancing motor function recovery in stroke patients (26, 27). This approach involves observing a task followed by its execution, activating cortical motor areas during both observation and execution. The mirror neuron network is particularly active when actions are observed with the intention to imitate (28). Such training has demonstrated positive effects on motor function recovery in stroke patients, attributed to the reactivation of motor areas containing mirror neurons responsible for the action observation and execution matching system (27).

Despite the potential benefits of action observation training, its impact on upper limb functional recovery, manual dexterity, and motor functions in acute stroke patients has been underexplored, with previous studies limited in scope and sample size (29, 30). The current study aims to fill this gap by examining a larger sample, providing more accurate insights into the comparative effects of action observation exercises with complex tasks versus conventional therapy on improving upper limb motor functions, manual dexterity, and functional recovery in acute stroke patients.

MATERIAL AND METHODS

The study was designed as a Randomized Control Trial, focusing on the comparison between two groups: the experimental group receiving action observation training and the control group undergoing conventional therapy. The sampling method employed was non-probability purposive sampling, with randomization achieved through the toss of a coin. In this method, participants were assigned to the experimental group if the coin toss resulted in heads, and the subsequent participant was then allocated to the control group. This procedure was uniformly applied to all participants.

Conducted at Rafsan Neuro Rehab Center in Peshawar, the study spanned a duration of six months following approval from the BASR. Inclusion criteria comprised both male and female participants aged between 40 to 75 years (31), in the acute phase of stroke (less than 3 months), with no cognitive impairments (MMSE >24), no visual or auditory abnormalities, preserved visual acuity, middle cerebral artery infarction, and a Fugl-Meyer assessment (FMA) score of 20 or above for upper limb status (31). Participants with a dominant hand were specifically selected. The exclusion criteria included individuals with posterior circulation infarction (14), comorbidities influencing voluntary upper-extremity function or history of multiple strokes, and those presenting with apraxia, agnosia, cognitive defects, or other neurological disorders.

The sample size was determined using OpenEpi, resulting in a total of 58 participants, with 29 in each group. The standard deviation and mean were derived from a previous study utilizing the Box and Block Test (32).

For outcome measures, the study employed the Fugl Meyer Assessment scale, a performance-based impairment index for post-stroke hemiplegic patients, known for its high test-retest reliability (ICC = 0.97) and concurrent validity (r = 0.94-0.95) (33, 34). The Box and Block test (BBT), used to evaluate manual dexterity of post-stroke patients, boasts excellent test-retest reliability (0.98) (35). The REACH scale, a self-report measure for stroke patients, assesses functional recovery in terms of the use of the affected arm in household and community tasks, with an inter-rater reliability of 0.91 (36).

Data collection took place at Rafsan Neuro Rehab Centre, Peshawar, where after obtaining informed consent from the participants, randomization was conducted using the aforementioned coin toss method. The rehabilitation protocol involved patients first observing custom-made exercise videos and then executing the observed exercises. This protocol was conducted three days a week for a total of eight weeks. Baseline assessments for both groups were carried out in the first week before implementing the protocol, with final assessments conducted in the eighth week. The study received approval from the Research Ethical Committee (REC).

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This double-blinded study ensured that neither the participants nor the assessors were aware of the group allocations during the baseline and final assessments. The intervention comprised two distinct groups: the experimental group, which participated in action observation exercises, and the control group, which received conventional therapy.

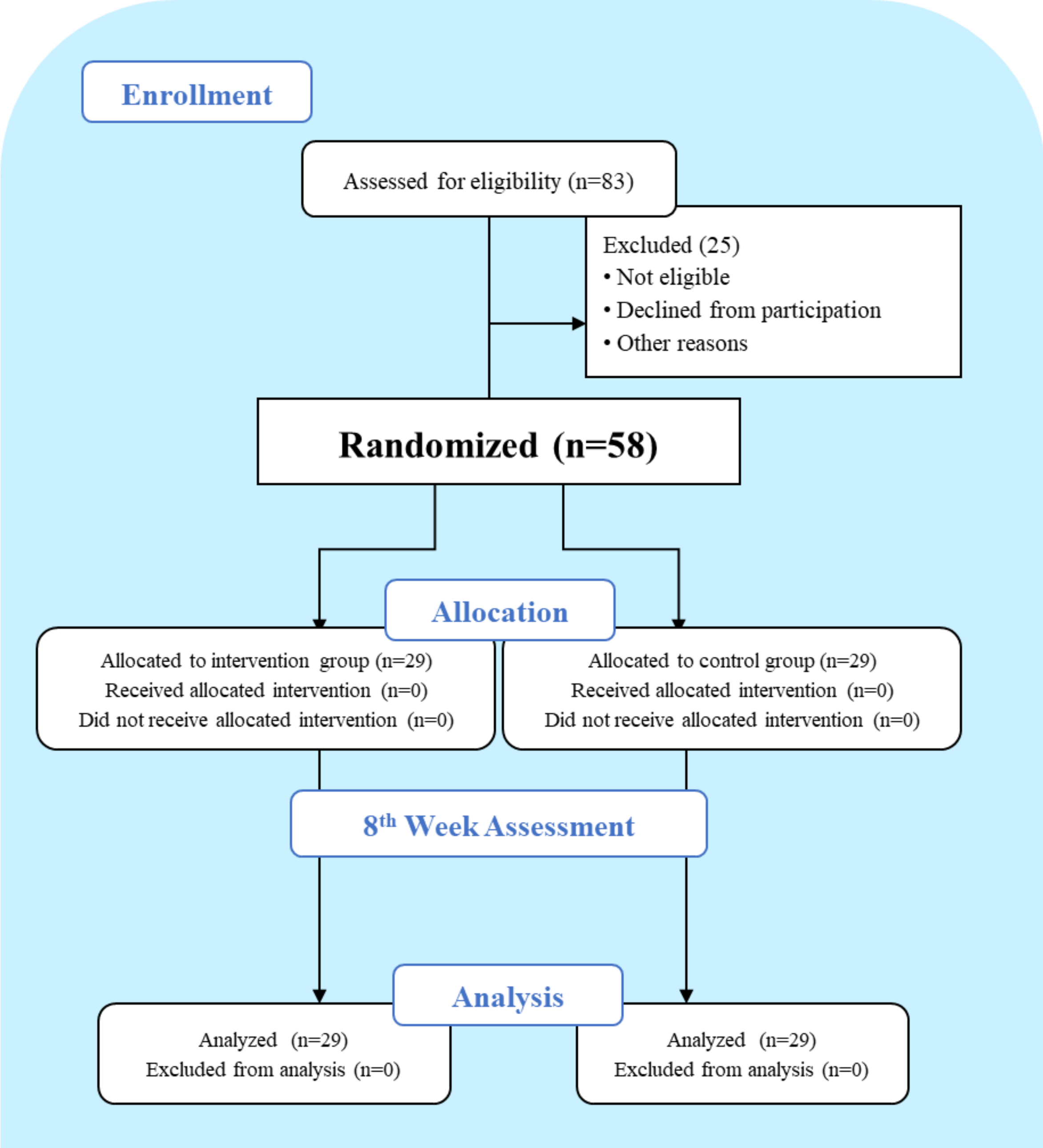

Figure 1 CONSORT Diagram

Data analysis was performed using SPSS version 25. Descriptive statistics provided frequency and percentages for categorical variables, and mean and standard deviation for continuous variables. The Shapiro-Wilk test was applied to assess data normality. The data for the Box and Block and Fugl Meyer scales, being normally distributed (Shapiro-Wilk value > 0.05), were subjected to parametric tests. The REACH scale, being categorical, underwent non-parametric testing. Between-group analyses for normally distributed data utilized the parametric independent sample t-test, while for categorical data, the non-parametric Mann-Whitney U test was applied. Within-group analysis for normally distributed data employed the parametric paired sample t-test, and for categorical data, the Wilcoxon signed-rank test was used.

RESULTS

In the study, a detailed examination of demographic characteristics and outcome measures was conducted to assess the efficacy of action observation training in comparison to conventional therapy in acute stroke patients. The participant's age ranged from 40 to 75 years, with the experimental group having an average age of 53.28 years (SD = 9.21) and the control group slightly older at an

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average of 54.83 years (SD = 9.64), resulting in an overall average age of 54.05 years (SD = 9.38) across both groups (Table 1). Gender distribution was skewed towards males in both groups, with 72.4% in the experimental group and 62.1% in the control group, totaling 67.24% of the entire study population. Females comprised 27.6% of the experimental group and 37.9% of the control group, accounting for 32.75% of all participants.

The type of stroke experienced by participants varied, with ischemic stroke being significantly more common, particularly in the control group, where 96.55% had ischemic strokes compared to 75.86% in the experimental group. Overall, ischemic stroke accounted for 86.20% of cases, whereas hemorrhagic stroke was less prevalent, observed in 24.13% of the experimental group and a mere 3.44% of the control group, representing 13.79% of all participants. Regarding the dominant side affected by the stroke, the right side was predominant in both groups (89.7% in the experimental group and 86.2% in the control group), making up 87.93% of the total participants. The left side was affected in 10.3% of the experimental group and 13.8% of the control group, totaling 12.06%. Marital status also varied, with a majority being married (79.3% in the experimental group and 75.9% in the control group), comprising 77.58% of the total participants, while 20.7% in the experimental group and 24.1% in the control group were unmarried, accounting for 32.41% of the total study population (Table 1).

Table 1 Demographic Characteristics

Variable	Experimental Group	Control Group	Overall
Age (years)	53.28 ± 9.21	54.83 ± 9.64	54.05 ± 9.38
Variables	Experimental Group	Control Group	Overall
Gender			
Male	21 (72.4%)	18 (62.1%)	39 (67.24%)
Female	8 (27.6%)	11 (37.9%)	19 (32.75%)
Type of Stroke			
Ischemic Stroke	22 (75.86%)	28 (96.55%)	50 (86.20%)
Hemorrhagic Stroke	7 (24.13%)	1 (3.44%)	8 (13.79%)
Dominant Side			
Right Side	26 (89.7%)	25 (86.2%)	51 (87.93%)
Left Side	3 (10.3%)	4 (13.8%)	7 (12.06%)
Marital Status			
Married	23 (79.3%)	22 (75.9%)	45 (77.58%)
Unmarried	6 (20.7%)	7 (24.1%)	13 (32.41%)

Table 2 Between Group Analysis of Fugyl Meyer Scale

	Experimental Group	Control Group	Mean Difference	P-value
Baseline	29.69 ± 5.04	27.00 ± 4.71	2.69	0.40
Post Treatment	57.31 ± 4.01	54.24 ± 5.14	3.06	0.01

The Between Group Analysis of the Fugyl Meyer Scale revealed significant improvements post-treatment. Initially, the experimental group's baseline score was 29.69 (SD = 5.04), slightly higher than the control group's 27.00 (SD = 4.71). Post-treatment scores increased to 57.31 (SD = 4.01) for the experimental group and 54.24 (SD = 5.14) for the control group. The mean difference between the groups' post-treatment scores was 3.06, with a significant p-value of 0.01, suggesting a more substantial improvement in the experimental group (Table 2).

Table 3 Within Group Analysis of Fugyl Meyer Scale

Variable	Pre (Mean±SD)	Post (Mean±SD)	Mean Difference (Mean±SD)	P-value
Fugyl Meyer (Experimental Group)	29.69 ± 5.04	57.31 ± 4.01	27.62 ± 4.27	0.001
Fugyl Meyer (Control Group)	27.00 ± 4.71	54.24 ± 5.14	27.24 ± 5.31	0.001

The Within Group Analysis of the Fugyl Meyer Scale also showed notable improvements within each group. In the experimental group, the Fugyl Meyer score improved from a baseline of 29.69 (SD = 5.04) to 57.31 (SD = 4.01) post-treatment, with a mean difference of 27.62 (SD = 4.27) and a highly significant p-value of 0.001. The control group exhibited a similar trend, with scores improving from a baseline of 27.00 (SD = 4.71) to 54.24 (SD = 5.14) post-treatment, resulting in a mean difference of 27.24 (SD = 5.31) and a p-value of 0.001. These findings highlight the effectiveness of both the action observation training and conventional therapy in improving motor functions in acute stroke patients, with a slight edge observed in the experimental group (Table 3).

DISCUSSION

In this randomized control trial, we investigated the effects of action observation training compared with conventional therapy on motor function, manual dexterity, and functional recovery in patients with acute stroke. Our findings revealed significant improvements in motor functions and functional recovery for complex tasks in the experimental group; however, improvements in manual dexterity were not statistically significant.

Previous research aligns with our findings. Denis et al. (2007) reported notable improvements in motor function after a 4-week treatment program in chronic stroke patients, supporting our observations of enhanced motor function in the experimental group (37). Similarly, Kathleen et al. (2015) focused on the impact of action observation training on cortical motor activity and motor function in stroke patients. Their use of functional MRI demonstrated that action observation training could activate brain cortical motor areas, aiding in motor function, learning, and relearning in post-stroke patients, findings that are consistent with the outcomes of our study (38).

Yu-Wei et al. (2019) conducted a randomized controlled trial to assess the effects of action observation training and mirror therapy in stroke patients. Their study, involving 21 participants over a 3-week period, reported significant functional recovery benefits from both action observation training and mirror therapy, suggesting these methods could be used interchangeably in stroke rehabilitation. This is in line with our study's findings, which demonstrated the efficacy of action observation training in enhancing hand dexterity and functional recovery (39).

In 2014, a study by Patrizio Sale et al. focused on the effects of action observation training on hand dexterity in ischemic stroke patients. They reported substantial improvements in both Fugyl Meyer and Box and Block scores after 4 weeks of treatment, with continued improvement over 4 to 5 months. These results corroborate our study's findings, as we observed increases in both the Box and Block and Fugyl Meyer scores following action observation training (40).

Jianming Fu et al. (2017) also explored the impact of action observation therapy on motor function and daily living activities in patients with cerebral infarction. They found significant improvements in experimental groups receiving action observation therapy along with conventional physical therapy, particularly in measures like the REACH scale, which assesses daily living activities. This aligns with our findings that action observation therapy can effectively improve activities of daily living (31).

Mei-Hong Zhu et al. (2015) conducted a trial on post-stroke patients, comparing routine rehabilitation with a combination of routine rehabilitation and action observation training. Their findings indicated greater improvements in the experimental group, particularly in the Fugyl Meyer scale, supporting our study's observations of the positive effects of action observation training (41).

Our study concluded that action observation therapy has statistically significant effects on manual dexterity, motor, and functional recovery in acute stroke patients. While between-group analyses showed significant results for all variables except for the Box and Block test, within-group analyses indicated that both treatments were effective in symptom reduction.

The study faced several limitations. The COVID-19 pandemic posed a significant challenge, as patients were hesitant to enroll in the study. Furthermore, the study did not include all stroke types and was conducted in a single center, limiting its generalizability.

Future research should focus on larger sample sizes to enhance generalizability and include a broader range of stroke subtypes to understand the effects of action observation training across different patient demographics. This comprehensive approach will provide a more in-depth understanding of the therapy's applicability and efficacy in diverse clinical settings.

CONCLUSION

The conclusion of this study underscores the effectiveness of action observation therapy in improving motor function and functional recovery in acute stroke patients, although its impact on manual dexterity remains inconclusive. These findings hold significant implications for stroke rehabilitation, suggesting that incorporating action observation training into therapeutic protocols could enhance recovery outcomes. This approach, especially in the context of acute stroke, presents a promising adjunct to conventional therapy, potentially offering a more holistic and effective rehabilitation strategy. However, the limited scope in terms of stroke types and the single-center nature of the study suggest a need for further research to generalize these findings across diverse patient populations and clinical settings.

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