Migration Letters

Volume: 21, No: S13 (2024), pp. 356-369

ISSN: 1741-8984 (Print) ISSN: 1741-8992 (Online)

www.migrationletters.com

"Comparative Effects Of Motor Relearning Program And Action Observation Therapy On Balance And Gait In Chronic Stroke Patients.''

Ayesha Nazir [1] Rahat Ayub[2] Tamknat Ilyas[3], Rabia Majeed[4], Aimen Zaheer[5], Meerab Habib[6] Sania Maqbool[7]

ABSTRACT

Background: *Cerebrovascular accident, commonly known as a stroke, is characterized by sudden clinical indicators of localized (or generalized) disruption to brain function, as well as symptoms that continue longer than 24 hours or result in death, with an obvious cause, usually of vascular origin. Cerebral vascular disease ranks third in terms of disability and is the second most common reason for death globally. 1 in 19 people die in this ratio. Stroke is a significant long-term cause of harm and is more disabling than lethal.*

Objective: *To compare the effects[1] of Motor Relearning program and Action Observation therapy on balance and gait in chronic stroke patients.*

Methods: *A randomized clinical trial was conducted on 34 chronic stroke patients of age between 50 to 70 years. Clinical trial registry number was IRCT2023101505732N1. Sample was collected from DHQ hospital Sahiwal and Ahmad Heath Complex Arifwala through non probability convenience sampling technique and then patients were randomly allocated to 2 groups by using lottery method. Group A received intervention Motor Relearning Program with conventional treatment and Group B received Action Observation Therapy with conventional treatment. Both groups received treatment sessions of 30 minutes along with 20 to 25 minutes of conventional physical therapy for three days a week, over a period of eight weeks. For the pre- and post-evaluation of all participants Berg balance scale, 10-m walk test and timed up and go test was used. Data was analyzed by using SPSS (Statistical package for Social Sciences) 25 version.*

Results: *Data was examined for normality using Shapiro-Wilk, and a significance value greater than 0.05 suggested that the data was normally distributed. Differences between the two groups were assessed using an independent sample t-test to establish baseline*

1. Ayesha Nazir (King Edward Medical University Lahore)
2. Rahat Ayub (Assistant Professor at University of Management & technology Lahore)
3. Tamknat Ilyas (Assistant Professor at University of Management & technology Lahore)
4. Rabia Majeed(Assistant Professor, Department of Physical Therapy & Rehabilitation SHS University of Management & technology UMT Lahore)
5. Aimen Zaheer (Government College University Faisalabad GCUF)
6. Meerab Habib (University of Lahore UOL)
7. Sania Maqbool lecturer, Department of Physical Therapy Lahore College for Women University, lahore.

Corresponding author: Dr.Sania Maqbool lecturer, Department of Physical Therapy Lahore College for Women University, Lahore. Address: PIA Housing Society Johar Town Lahore, Pakistan. E-mail : saniamaqbool28@gmail.com

comparability. Changes within the same group were assessed using a paired sample t-test to evaluate the difference between pre-intervention and post-intervention data. Significant changes were observed in both groups when comparing pre and post-intervention outcomes

Conclusion: *This study concluded that Motor Relearning Program was more effective than action observation therapy in improving balance and gait in chronic stroke patients.*

Key words: *Action Observation therapy, Balance and gait rehabilitation, Motor Relearning program, Physiotherapy, Stroke rehabilitation.*

Word count of Abstract: 357

Word count of manuscript: 3687

1. INTRODUCTION

The World Health Organization characterizes a stroke as the sudden onset, lasting for more than 24 hours, of clinical symptoms indicative of a specific (or widespread) disruption of cerebral function, often resulting in a fatal outcome, with an evident vascular supply obstruction as the primary cause.(1) Meanwhile, a transient ischemic attack is defined by an international organization as a focal, acute neurological impairment with symptoms persisting for less than a day.(2)The majority (85%) of strokes fall into the category of ischemic strokes, primarily attributed to small vessel arteriosclerosis, cardio- embolism, and large artery Atheros-thromboembolism.(3)

Among the 795,000 new stroke cases, 26% of individuals, according to the Framingham cohort, endure disability in the basic activities of daily life, and 50% experience reduced movement as a result of hemiparesis. Apart from physical limitations, aphasia and depression are common culprits adding to the burden of disability caused by stroke.(4)

Women tend to live longer than males do, and they also have greater rates of important stroke risk factors like atrial fibrillation and hypertension. These variables may contribute to women's higher risk of stroke.(5) However, Particularly important concerns are the dangers connected to pregnancy and the postpartum phase. Recognizing and understanding these multifaceted influences on stroke risk in women is crucial for developing targeted prevention and intervention strategies that address the unique challenges faced by women in various stages of life.(6)

The Motor Relearning Program (MRP) represents a rehabilitative strategy primarily employed with individuals who have experienced a stroke. This method, which has its roots in a theory of motor learning, includes doable recommendations for the retraining of functional capabilities such balanced sitting, sitting and standing, transfer skills, and gait.(7) In order to enhance active movement control, the MRP focuses a strong emphasis on task-specific learning, combining controlled practice and appropriate feedback. (8)The MRP places less emphasis on facilitation techniques than approaches that extensively rely on them. Rather, it emphasizes how crucial manual guiding, verbal instruction, and demonstration are to the recovery process. The objective of this technique is to maximize functional recovery and motor relearning in stroke survivors.(9, 10)

The Motor Relearning Program (MRP) follows a structured approach encompassing four distinct steps: analyzing the task, practicing any missing components, practicing the entire task, and transferring learned skills to real-life situations.(11) A review of the literature has demonstrated the efficiency of the MRP in enhancing the functional recovery of those

individuals who have experienced a stroke. This approach's emphasis on systematic task analysis, targeted practice, and the gradual transfer of skills to real-life scenarios contributes to its positive outcomes in stroke rehabilitation.(12)

Action Observation (AO) is the process of actively watching purposeful actions with the intent of imitating and practicing them. Action Observation Therapy (AOT) is a multi-sensory approach rooted in basic neuroscience, involving somatosensory and cognitive rehabilitation. This method activates the mirror-neural system (MNS) of the brain.(13)Recent studies show that simply observing a particular action activates the same cortical brain areas dedicated to that motor function. This aids in movement planning and neuroplasticity.(14)

AOT typically involves both action observation and execution, providing patients with a safe way to practice movements and motor tasks.(15)

Stroke patients often grapple with lower limb functional disability, necessitating effective rehabilitation strategies. The study's findings shed light on the positive impacts of Motor Relearning Program (MRP) and Action Observation Therapy (AOT) for stroke patients dealing with lower extremity weakness. Persons with mild or moderate post-stroke hemiparesis are the main subject of this investigation. The study aims to raise awareness about these intervention regimens, offering safe options for stroke patients to follow at home and thereby reducing activity restrictions. The hope is that this research serves as a reliable guide for clinicians in selecting appropriate exercise programs and helps scientists identify research gaps and future directions in stroke rehabilitation for lower limb issues.

2 METHODOLOGY:

The study design was Randomized Clinical Trial. Clinical trial registry number was IRCT2023101505732N1.Sample size was calculated through EPITOOL Software. The estimated sample size was 30 after adding 10% attrition rate it was 34. Seventeen in each group. Sample technique was Non-Probability Convenience sampling. The study was conducted in DHQ hospital Sahiwal and Ahmad Health Complex Arifwala.The study was completed within 6 months after the approval of synopsis.

Inclusion Criteria	**Exclusion Criteria**
•Those who were diagnosed with cerebral hemorrhage and cerebral infarction based on computed tomography or magnetic resonance imaging. •Both male and female •Patients age 50-70 years •Chronic stroke patients (after 6 months of first stroke) •Medically stable patients having a single stroke •No visual field defects •No abnormality in the vestibular organs •A score greater than 24-30 in mini-mental test •Patients that will be able to fulfill and comprehend the command.	•Patients with orthopedic diseases (such as contracture) in the trunk and both lower extremity. •History of fall in last 6 months. •A history of other neurological diseases or disorders (Multiple Sclerosis, Parkinson's) •Manual muscle testing below grade II. •Individuals undergoing additional related therapy as part of the trial, which could have an impact on the research's effectiveness. •Individuals who are not medically fit to begin rehabilitation, such as those with unstable angina, uncontrolled diabetes, or severe uncontrolled hypertension**.**

•2–4 muscle power on the impacted side (MRC Muscle Scale 2–4	

Group A - Experimental group (n=17):	**Group B - Experimental group (n=17):**
Patients in group A were treated by Motor Relearning program and Conventional physical therapy (A session of 40 minutes for 8 weeks including 3 sessions per week) **CONVENTIONAL THERAPY:** Conventional therapy was given to both groups. Patients underwent 20-minute session for 8 weeks including 3sessions per week.(60)	Group B was treated by Action Observation Therapy and Conventional physical therapy (A session of 40 minutes for 8 weeks including 3 sessions per week) **CONVENTIONAL THERAPY:** Conventional therapy was given to both groups. Patients underwent 20-minute session for 8 weeks including 3sessions per week.

1.1 Intervention:

Exercises included in conventional therapy:

1	This involves performing range of motion exercises for the lower extremities, encompassing passive and active-assisted movements for the hip, knee, and ankle joints.
2	Gradual and progressive stretching of muscles, focusing on areas such as the quadriceps, hamstrings, and calf muscles.
3	Completing isometric strengthening exercises for the trunk and quadriceps.
4	Balance training includes exercises where individuals practice reaching beyond arm's length while in seated and standing positions.
5	Walking training incorporates dynamic balance challenges, including activities like walking on diverse surfaces and navigating obstacle courses. (60)

GROUP – A		
Treatment technique: Instruction focused on specific tasks using the Motor Relearning method was performed for group A along with conventional therapy. Every training session consisted of 05 training tasks which were completed within 20 minutes: (A session of 20 minutes for 8 weeks including 3 sessions per week).		
1	**Bed mobility and sitting up over the side of the bed:** This involves exercises for bed mobility, including rolling and bridging, followed by transitioning from a supine position to sitting at the edge of the bed	1 set of 10 Repetitions
2	**Balanced sitting:** Head and trunk movements in sitting position with feet and knees approximately 15 cm apart and multidirectional reaching activities.	1 set of 10 repetitions
3	**Standing up and sitting down:** Sitting on a level, hard surface without armrests, one begins standing up by flexing the hips, knees, and ankles. Next, one places their feet backward and raises their upper body vertically.	1 set of 10 repetitions
4	**Balanced standing:** Posing with feet apart, head and trunk movements, and reaching in different directions.	1 set of 10 repetitions
5	**Practice of walking components:** The practice of walking itself comes after the practice of walking components**.**	1 set of 10 repetitions

GROUP-B		
TREATMENT TECHNIQUE: In the action observational gait training group (group B), participants witnessed a real life demonstration or watched a video featuring a healthy individual illustrating walking on various terrains at normal and double speed, with one-minute breaks between each segment for 5 minutes. Subsequently, participants underwent five-minute walking training sessions on flat ground, obstacle walking, and steps, replicating the activities from the video. These sessions were separated by 1–2 minute breaks. The entire walking training, lasting 20 minutes, occurred three times per week for 8 weeks.(56)		
	WALKING TRAINING	
1	**On flat land:** (straight walking, walking with head turned to left and right, and side walking)	5-minutes training
2	**Obstacle walking:** (walking over obstacles, turn the obstacle clockwise, turn the obstacle counterclockwise)	5-minutes training
3	**On steps:** (up stair and down stair)	5-minutes training

3. RESULTS:

Table.1 Age Distribution:

The table showed the age of participants involved. The frequencies of all the specific age groups were demonstrated in this table.

Participant Age		Frequency	Percent
Group A	50-60	09	52.9
	61-70	08	47.1
	Total	17	100
Group B	50-60	08	47.1
	61-70	09	52.9
	Total	17	100

Table: 1 showed the age distribution between two groups, Groups (A & B). Both groups comprised 17 participants each. In both Groups (A & B), the age distribution was as, with participants having 50-60 age group were 52.9% in group A, in group B was 47.1% while participants with 61-70 age were 47.1% in group A and in group B was 52.9% respectively.

Table 2 Gender Distribution:

The table of gender distribution demonstrated that out of total 34 participants there were 11 males and 23 females in both groups.

Participant Gender		Frequency	Percent
Group A	Male	07	41.2
	Female	10	58.8
	Total	17	100.0
Group B	Male	04	23.5
	Female	13	76.5
	Total	17	100.0

Table: 2 showed the gender status among two groups, Groups (A & B). Both groups comprised a total of 17 participants each. In both Groups (A & B), the gender distribution was as, with 41.2% (07) being males in group A, 23.5 %(04) in group B and being females 58.8% (10) in group A while 76.5% (13) in group B respectively.

Table 3 Occupation Status:

The table of occupation distribution demonstrated that out of total 34 participants there were 07 employed and 27 unemployed in both groups.

Participant Occupation Status		Frequency	Percent
Group A	Employed	05	29.4
	Unemployed	12	70.6
	Total	17	100.0
Group B	Employed	02	11.8
	Unemployed	15	88.2
	Total	17	100.0

Table: 3 showed the occupation status among two groups, Groups (A & B). Both groups comprised a total of 17 participants each. In both Groups (A & B), the occupation distribution was as, with 29.4% (05) being employed in group A, 11.8 % (02) in group B and being unemployed 70.6% (12) in group A while 88.2% (15) in group B respectively.

Table 4: Physical Activity

The table of physical activity status demonstrated following stats:

Participant Physical Activity		Frequency	Percent
Group A	Sedentary	03	17.6
	Light	08	47.1
	Moderate	03	17.6
	Vigorous	03	17.6
	Total	17	100.0
Group B	Sedentary	01	5.9
	Light	13	76.5
	Moderate	02	11.8
	Vigorous	01	5.9
	Total	17	100.0

Table: 4 showed the Physical activity among two groups, Groups (A & B). Both groups comprised a total of 17 participants each. In both Group A, the Physical activity distribution was as sedentary 03(17.6%), light 08(47.1%), moderate 03(17.6%) and vigorous was 03(17.6%) while in group B the values were 01(5.9%), 13(76.5%), 02(11.8%) and 01(5.9%) respectively

Table 6: Mean Comparison in Group A and B by Ind. Samples t-Test:

BETWEEN GROUP STUDIES OF BERG BALANCE SCALE:

Berg's Balance Scale	**Group A**		**Group B**		**P-value**
Pre intervention	Mean	S.D	Mean	S.D	0.37
	27.82	±5.60	25.80	±2.78	
Post intervention	51.35	± 5.53	44.70	± 4.52	0.00

According to the table comparing group studies using the Berg balance scale, group A's pre-

intervention score was 27.82 ±5.60, whereas group B's score was 25.80 ±2.78. Following the intervention, group A scored 51.35 ± 5.53, while group B scored 44.70 ± 4.52. The independent sample t test reveals a significant difference between the pre-intervention and intervention times, with an observed p-value of less than 0.05.

Table 7: Between Groups Studies Of Timed Up And Go Test:

Timed up and Go Scale	**Group A**		**Group B**		**P-value**
Pre intervention	Mean	S.D	Mean	S.D	0.49
	15.47	±1.50	14.82	±2.35	
Post intervention	8.44	±1.57	9.29	±1.96	0.05

Group A's pre-intervention score was 15.47 ±1.50, whereas group B's was 14.82 ±2.35, according to a table comparing group studies using the Timed up and Go test scale. Group B scored 9.29 ± 1.96 and Group A scored 8.44 ± 1.57 after the intervention, respectively. The independent sample t test revealed a significant difference between the pre-intervention and post intervention times, with an observed p-value of less than 0.05.

TABLE 8: BETWEEN GROUP STUDIES OF 10 M WALK TEST:

10 M walk test	**Group A**		**Group B**		**P-value**
Pre intervention	Mean	S.D	Mean	S.D	0.043
	19.23	± 2.48	19.17	± 2.89	
Post intervention	7.64	± 1.76	9.47	± 1.58	0.051

According to a table comparing group studies using the 10 M walk test scale, group A's pre-intervention score was 19.23 ±2.48, whereas group B's was 19.17 ±2.89. Group A's post-intervention scores were 7.64 ± 1.76 and group B's were 9.47 ± 1.58, respectively. Given that the observed p-value was less than 0.05, the independent sample t test revealed a significant difference both at baseline and following the intervention.

Table 9: Baseline to Week 8 Paired difference in Group A:

GROUP A	MEAN + S.D	Mean diff	P-value
Berg Balance scale at baseline	**27.82 ±5.60**	**-17.52**	0.000
Berg Balance scale at 8 weeks	**51.35 ± 5.53**		
Timed up and Go test at baseline	**15.47 ±1.50**	**7.029**	0.000
Timed up and Go test at 8 weeks	**8.44 ± 1.57**		
10 M walk test at baseline	**19.23 ± 2.48**	**11.588**	0.000
10 M walk test at 8 weeks	**7.64 ± 1.76**		

Table results showed, the paired sample t-test conducted inside Group A demonstrated a notable difference in the BBS baseline Score to Week 8. The mean BBS Score at baseline was 27.82, and it differenced to 51.35 at Week 8 ($p < 0.001$). This indicates a substantial improvement in the BBS assessment score experienced by participants in Group A.

Group A participants also exhibited notable enhancement in Timed up and Go Test baseline to post-intervention. The mean TUG Score differenced from 15.47 at baseline to 8.44 at the post- intervention stage ($p < 0.001$). This suggested a notable reduction in TUG score burden within the study group. And similarly participants also showed considerable improvement in 10 M walk test as obvious from stats.

Table 10: Baseline to Week 8 Paired difference in Group B:

GROUP B	MEAN + S.D	Mean diff.	P value
Berg Balance scale at baseline	**25.80 ±2.78**		0.000

Berg Balance scale at 8 weeks	**44.70 ± 4.52**	**-18.90**	
Timed up and Go test at baseline	**14.82 ±2.35**	**5.53**	0.000
Timed up and Go test at 8 weeks	**9.29 ± 1.96**		
10 M walk test at baseline	**19.17 ± 2.89**	**9.70**	0.000
10 M walk test at 8 weeks	**9.47 ± 1.58**		

Table results showed, the paired sample t-test conducted inside Group B demonstrated a notable difference in the BBS baseline Score to Week 8. The mean BBS Score at baseline was 25.80, and it differenced to 44.70 at Week 8 ($p < 0.001$). This indicates a substantial improvement in the BBS assessment score experienced by participants in Group A.

Group A participants also exhibited notable enhancement in Timed up and Go Test baseline to post-intervention. The mean score differenced from 14.82 at baseline to 9.29 at the post-intervention stage ($p < 0.001$). This suggests a notable reduction in TUG score burden within the study group. And similarly participants also showed considerable improvement in 10 M walk test as obvious from stats.

DISCUSSION

The objective of the current study was to assess how the Motor Relearning program and Action Observation therapy affected the balance and gait in those with chronic stroke. The study's findings provide significant new information on how well these two rehabilitation methods work for treating chronic stroke patients. The findings exhibited that both techniques showed positive results within groups but comparing the results of Motor Rearming Program with the Action Observation Therapy showed that Motor Relearning Program was much more effective to improve gait and balance. These findings emphasize the need of including MRP into rehabilitation programs for stroke people looking for improvements in gait and balance.

This was conversely, with a review directed by Oscar Eduardo Mateus-Arias (2023) that motor relearning program in patients with stroke. The Cochrane Manual's risk of bias assessment was applied, and the PEDro scale was used to evaluate the methodological quality. Out of the possible 984 studies, eight were included. Results: The motor relearning groups showed a clinically significant improvement, and in just one trial was this improvement significant when compared to a different intervention. In conclusion, the application of the motor relearning program has a substantial clinical impact. This was in favor of this study that Motor Relearning Program was effective with value of **$p<0.05$**.(10)

Another study conducted by Amer Ghrouz in 2023, participants was randomized into two

groups: the CPT group (n=31), receiving traditional physical therapy and the MRP group (n=32), receiving task-specific training based on Motor Relearning Program (MRP). Both groups underwent an 8-week intervention, consisting of three sessions per week, each lasting one hour. Evaluation of balance and postural control was performed using the Berg Balance Scale (BBS) and post urography at baseline, after the intervention, and at the 3-month follow-up. Following the intervention, the MRP group demonstrated significantly greater gains in both Berg Balance Scale (BBS) scores (p=0.001, d=2.98, 95% CI [2.25, 3.70]) and Balance Index scores (p=0.001, d=2.83, 95% CI [2.12, 3.53]) compared to the CPT group. These gains were sustained at the three-month follow-up. However, in this study, the post-group analysis yielded significant results with a p-value less than 0.05.(16)

One more concentrate by Raghumahanti Raghuvee (2023) this study aimed to evaluate the impact of the Motor Relearning Program (MRP) and modified Constraint-Induced Movement Therapy (CIMT) on balance and gait in sub-acute hemiplegic stroke patients. Each group was comprised of 17 participants, randomized using a computer-generated system and the opaque sealed envelope technique. Outcome measures include the Berg Balance Scale, Dynamic Gait Index, Trunk Impairment Scale, Functional Reach Test, 10 Meter Walk Test, and Fall Efficacy Test. Assessments was conducted at baseline and six weeks later. Despite existing evidence supporting improved functional mobility and balance with physiotherapy for stroke victims, this study seeks to compare the effectiveness of CIMT and MRP in sub-acute stroke subjects, with preliminary findings indicating that the motor relearning technique was more effective.(17)

In a recent report, Anmol Narang (2023) conducted a study comprised of three equal groups, each with fifteen patients, and they were randomly selected from 45 post-stroke patients who had upper limb impairment. Group A underwent the Motor Relearning Programme (MRP) along with Conventional Physiotherapy (CPT), Group B received Mirror Therapy (MT) in addition to CPT, and Group C exclusively underwent CPT. The intervention spanned eight weeks with five one-hour sessions per week. Outcome measures, including the Chedoke Arm and Hand Activity Inventory Scale (CAHAI), Fugl Meyer Assessment of Physical Performance of the Upper Extremity (FMA-UE) Scale, and Motor Assessment Scale (MAS), were used to assess the effectiveness of the interventions. In the current study, a paired sample t-test conducted within Group A indicated a significant difference in the Berg Balance Scale (BBS) scores between baseline and Week 8. The baseline mean BBS score was 27.82, and it significantly increased to
51.35 at Week 8 ($p < 0.001$). This signifies a considerable improvement in the BBS assessment scores for participants in Group A.(18)

As opposed to a concentrate by Kanchan- 2023, In this study, thirty post-stroke patients with upper limb disability were randomly assigned to two groups: Group A, undergoing constraint-induced movement therapy (CIMT), and Group B, participating in a motor relearning program (MRP). The intervention, consisting of five sessions per week over eight weeks, lasted for an hour each. Post-intervention, Group A exhibited significantly higher improvement in all metrics compared to Group B ($p < 0.05$). Notably, in terms of motor function and degree of handicap, Group A (CIMT) displayed more pronounced improvement than Group B (MRP).The BBS baseline Score to Week 8 differed significantly from Group A, according to the paired sample t- test. At baseline, the mean BBS Score was 27.82; by Week 8, it had changed to 51.35 ($p < 0.001$)

Another study conducted by Hewei Wang (2021) randomly assigned 39 stroke patients with moderate to severe upper limb motor disability to the MIT or control groups. While the control group only received conventional rehabilitation, the MIT group's patients underwent

conventional rehabilitation in addition to four weeks of MIT therapy. All patients had fMRI scanning utilizing a passive hand movement task, as well as assessments of the Barthel Index (BI) and the Fugl-Meyer Upper Limb Scale (FM-UL) before and after treatment**.** A significant improvement was seen in FM-UL in both groups (MIT before and after intervention:16.73 ± 11.06 vs. 31.59 ± 13.50, p<0.001; CON before and after intervention: 16.82 ± 12.91 vs.22.88 ± 19.71, p = 0.001. Group A's pre-intervention score on the Berg balance scale is 27.82±5.60, whereas group B's score is 25.80 ±2.78. Group A's post-intervention scores are 51.35 ± 5.53, while group B's scores are 44.70 ± 4.52. Independent sample t test shows significant difference at baseline and after the intervention as observed p-value is less than 0.05.(19)

This study makes a significant contribution to the field, opening avenues for further research and potential improvements in stroke management. Both techniques have positive effects on patients' balance and gait, which supports their effectiveness in managing stroke. Future research should focus on mitigating the study's limitations to further enhance the understanding and application of these techniques.

CONCLUSION : This study concluded that Motor Relearning Program was more effective than Action Observation Therapy in improving balance and gait in chronic stroke patients.

6. Consent for publication: The study's goals were explained to the participants, and written informed consent was obtained.

7. Competing interests: There are no competing ideas declared by the authors. The study's findings are given simply and honestly, with no exaggeration, manipulation, or improper deletion of information.

References:

1. El-Hajj M, Ajrouche R, Zein S, Rachidi S, Awada S, Al-Hajje A. Evaluation of risk factors and drug adherence in the occurrence of stroke in patients with atrial fibrillation. Pharmacy Practice (Granada). 2020;18(2).
2. Fodor DM, Marta MM, Perju-Dumbravă L. Implications of circadian rhythm in stroke occurrence: certainties and possibilities. Brain Sciences. 2021;11(7):865.
3. Serlin Y, Shelef I, Knyazer B, Friedman A, editors. Anatomy and physiology of the blood–brain barrier. Seminars in cell & developmental biology; 2015: Elsevier.
4. Kim J, Thayabaranathan T, Donnan GA, Howard G, Howard VJ, Rothwell PM, et al. Global stroke statistics 2019. International Journal of Stroke. 2020;15(8):819-38.
5. Kotov SV, Isakova EV, Kolchu IG, Belkina SN. The effect of modifiable stroke risk factors on systemic thrombolytic therapy in patients with acute stroke. Annals of Clinical and Experimental Neurology. 2021;15(1):21-31.
6. Alloubani A, Saleh A, Abdelhafiz I. Hypertension and diabetes mellitus as a predictive risk factors for stroke. Diabetes & Metabolic Syndrome: Clinical Research & Reviews. 2018;12(4):577-84.
7. Subazwari SAB, Abrar A, Shahid Z, Manzoor S, Hadiqa H, Shafique HI. Comparison of Effects of Neurodevelopmental Treatment versus Motor Relearning Program on Upper Limb Spasticity in Chronic Stroke Patients. A Randomized Control Trial. Int Med J. 2021;29:7723-9.
8. Rauf R, Rashad A, Noreen A, Intikhab R, Suleman TA, Mughal S. Comparison of mirror therapy and motor relearning program in improving the upper limb motor function of patients with stroke. Pakistan Armed Forces Medical Journal. 2021;71(4):1364-67.
9. Kanase SB. Effect of motor relearning programme and conventional training on functional mobility in post stroke patients. Indian Journal of Public Health Research & Development. 2020;11(5):496-501.

10. Mateus-Arias OE, Camperos-Toro A, Rangel-Silva A, Mantilla-Toloza S, Martínez-Torres J. Motor relearning program in patients with stroke sequels: a systematic review. Duazary Revista de la Facultad de Ciencias de la Salud. 2023;20(1).
11. Jan S, Arsh A, Darain H, Gul S. A randomized control trial comparing the effects of motor relearning programme and mirror therapy for improving upper limb motor functions in stroke patients. JPMA. 2019;69(1242):2019.
12. Maratis J, Wahidin A, Ivanali K, editors. COMPARE THE EFFECTIVENESS OF CONSTRAINT INDUCED MOVEMENT THERAPY AND MOTOR RELEARNING PROGRAMME IN POST STROKE PATIENTS. Academic Physiotherapy Conference Proceeding; 2021.
13. Zhang JJ, Fong KN, Welage N, Liu KP. The activation of the mirror neuron system during action observation and action execution with mirror visual feedback in stroke: a systematic review. Neural plasticity. 2018;2018(1):2321045.
14. Yoshimura M, Kurumadani H, Hirata J, Osaka H, Senoo K, Date S, et al. Virtual reality-based action observation facilitates the acquisition of body-powered prosthetic control skills. Journal of NeuroEngineering and Rehabilitation. 2020;17:1-12.
15. Buccino G, Molinaro A, Ambrosi C, Arisi D, Mascaro L, Pinardi C, et al. Action observation treatment improves upper limb motor functions in children with cerebral palsy: a combined clinical and brain imaging study. Neural plasticity. 2018;2018(1):4843985.
16. Ghrouz A, Guillen-Sola A, Morgado-Perez A, Muñoz-Redondo E, Ramírez-Fuentes C, Curbelo Pena Y, et al. The effect of a motor relearning on balance and postural control in patients after stroke: An open-label randomized controlled trial. European Stroke Journal. 2024;9(2):303-11.
17. Chavan NS, Raghuveer R. Lower limb rehabilitation using modified constraint-induced movement therapy and motor relearning program on balance and gait in sub-acute hemiplegic stroke: a comparative study. F1000Research. 2024;12:1098.
18. Narang A, Arora L, Arora R. Comparison of Effects of Motor Relearning Programme and Mirror Therapy on Upper Extremity Functions in Post-Stroke Patients–A Randomized Control Trial. European Journal of Medical and Health Sciences. 2023;5(4):68-73.
19. Wang H, Xiong X, Zhang K, Wang X, Sun C, Zhu B, et al. Motor network reorganization after motor imagery training in stroke patients with moderate to severe upper limb impairment. CNS neuroscience & therapeutics. 2023;29(2):619-32.