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Effects of joint integrity exercises versus mirror therapy on proprioception and functional rehabilitation of upper limb in hemineglect stroke survivors

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Original Article

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ABSTRACT

Objective: To compare the effects of joint integrity exercises and mirror therapy to see which intervention was more successful in enhancing proprioception and motor function of the upper limb in hemineglect stroke survivors.

Methodology: This was randomized clinical trial study. This study was registered on clinical trial.gov with the registration number NCT03827135. Non-probability convenient sampling technique was used to collect the data. Following the line bisection test, patients who had suffered from hemineglect strokes were divided into two groups, Group A and Group B depending on the treatment method used. Sessions were held 3 days a week. Data was gathered from two groups using the Fugl-Meyer Assessment, Revised Nottingham Sensory Assessment, and Motor Assessment Scale at baseline=0 week, at 3 weeks, and after 6 weeks. Version 21 of SPSS for Windows was used to analyze the data.

Results: The mean age and standard deviation of patients was 53.86±3.48 for joint integrity exercises group with 28.57% male and 71.43% female population while 52.36±4.81 for mirror therapy group with 42.86% male and 57.14% female population. Post treatment P-value of sensation component of FMA.U.E, motor component of wrist joint and RNSA is less than 0.05, showed that joint integrity exercises were more effective on sensory component of U.E and motor component of wrist joint while graphical representation of MAS score showed mirror therapy more effective on motor component of upper extremity. Results of spearmen's rho showed that proprioception and functional rehabilitation were positively correlated with each other. In clinical settings, use of both interventions i.e joint integrity exercises and mirror therapy are effective to recover sensory and motor functions of U.E respectively.

Conclusion: Joint integrity exercises were more effective on sensory component of upper extremity and proprioception positively correlated with function rehabilitation of upper limb.

Introduction:

Globally, stroke is a leading cause of illness and mortality.(1) We can define it as "Rapidly developing clinical symptoms and signs of focal, and at times global, loss of cerebral function, with symptoms lasting more than 24 hours or leading death, with no apparent cause other than that of vascular origin". The most prevalent and leading cause of disability worldwide is stoke.(2) In the entire world, it is the second leading cause of death. (3) Prevalence of stroke is higher in females than males. (4)

Ischemic stroke is the most prevalent type of stroke.(5) The primary factor of disease burden worldwide is ischemic stroke, which is a stroke caused by brain ischemia that interrupts or reduces flow of blood to a portion of the brain.(6) The prevalence of ischemic stroke is higher than hemorrhagic stroke, 66.8% and 33.2% respectively. (7) Functional outcomes for individuals with ischemic stroke showed improvement in both sexes as compared to hemorrhagic stroke patients. (8) Transient ischemic attack is another form of stroke (TIA), also called minor stroke because its symptoms resolve within 24 hours of ischemic attack.(9)

The middle cerebral artery (MCA) is the artery that is most frequently involved in strokes. Different lobes of brain which involved in motor control, motor learning and executive functions are all supplied by MCA.(10). The dominant hand of the patient indicates which side of the brain is being affected by a stroke. According to a study, majority of patients used their right hand as dominant hand.(11) Despite the possibility of lower extremity involvement, the symptoms often first appear and severe in the upper extremity. One more symptom of MCA syndrome is hemineglect in those patients.(10)

Hemineglect is a prevalent, incapacitating condition among stroke victims. Neglect develops when patients who are unable to examine their environment seem to "ignore" some aspect of it. It is the inability to perceive and react to stimuli on the side of the body affected. Patients with left sided hemiplegia

frequently experience it.(12) About 30% of stroke patients have hemineglect.(13) By following the line cancellation test or the line bisection test to the patients, it can be evaluated.(14) Patients with hemineglect have poor functional performance in the sub-acute phase. Neurorehabilitation still pays little attention to treating sensations, and there is limited support for rehabilitation by sensory training. According to the literature, proprioception and motor performance in hemineglect patients can be improved by kinesthetic stimulations. Hemineglect stroke patients can get benefit from tactile stimulation and joint integrity exercises for enhancing proprioception and motor response in them.(15)

One of the typical sensory deficits following a stroke is proprioceptive deficit, which has a detrimental effect on motor function. Proprioception, which is acquired from the skin, joints, tendons, and muscle spindle receptors, enables us to feel the position and movement of the body (16) The perception of force, position and balance of a limb is described as proprioception. The brain incorporates afferent proprioception signals during voluntary movement to create an effective motor plan and continuously modify motor performance based on proprioceptive feedback.(17)

After a stroke, about 50% of patients have upper limb proprioception deficits that impair their motor control and functional learning.(18) The efficacy of sensory training for enhancing upper limb function, is still debatable because of the limited research and variety of methods and approaches.(19) After stroke, recovery of motor function and improvement in proprioception is facilitated by a variety of rehabilitation techniques, including motor training and repeated somatosensory stimulation.(20) Patient can feel an illusion of position or movement in the affected limb if tactile stimulation is applied on affected limb, which helps to improve proprioception.(21) Among those patients who have survived from a stroke, sensory input can trigger a motor response. (7)

Another research indicates that mirror therapy can help hemineglect stroke patients to improve their motor skills.(22) Mirror therapy is important in assisting neglect stroke sufferers to regain their motor and sensory abilities. It is based on the idea of neuroplasticity. Evidence has shown that MT has an immediate positive impact on stroke patients' motor rehabilitation. According to previous literature, mirror therapy helps stroke patients to recover from hemineglect strokes by improving their ability to perform ADLs and motor activities of the upper extremity. (23)

METHODOLOGY

The study were recruited 28 patient that meet the inclusion criteria, Neurophysician referred the hemineglect stroke to Rehabilitation Department of Wapda Hospital, Lahore for Rehabilitation from May 2022 to October 2022, having sub-acute stroke for the first time, aged between 45 to 60 years, both males and females, minimum score > 24 in Mini-Mental State Examination, Catherine Bergego scale score > 0 and MIQ-3 score ≥ 6 were included and patients with chronic stroke, having upper limb fractures before stroke and having other neurological conditions before stroke including Parkinson's patients, individuals with Alzheimer's disease and patients of Multiple sclerosis were excluded. Two comparable approaches i.e joint integrity exercises and mirror therapy are used to assess their effectiveness in hemineglect stroke patients. Fugl-Meyer Upper Extremity Assessment (to assess motor and sensory component of upper extremity), Motor Assessment Scale (to assess motor function of upper extremity) and Revised Nottingham Sensory Assessment (to assess sensations of upper extremity) were used as outcome measures.

TREATMENT PROTOCOL

These outcome measures were assessed at three different time points: baseline (before treatment), in-between (during the third week), and after (end of sixth week). Recovery within first 3 weeks is speedy and comparable with results of 6 weeks treatment protocol. 28 patients with hemineglect stroke who met the inclusion and exclusion criteria were randomly divided into two groups, with 14 individuals in each group. All participants gave their informed consent after being informed about the study.

Group A: Joint integrity exercises group

The patients were treated with three strokes of tactile stimulation using a variety of textures (cotton wool ball, pinprick, pressure with index finger, apply hot and cold water bottles in random sequence, and bilateral simultaneous touch), followed by a 3 second rest period. In a sitting position, patients received kinaesthetic stimulations to improve proprioception in a neglected limb. The examiner moved the limb on the affected side of the body in various directions, but only one joint at a time. The patient was instructed to mimic the new movement with the opposite limb. Stereognosis by asking the patient hold the object with their eyes closed for no more than 30 seconds. Identification methods included naming, describing, or matching pairs of objects from the same collection. First, the affected side of the body was examined.

Group B: Mirror Therapy group

Patients were seated near to the table if they pass the movement imagery questionnaire. A 5 cm x 35 cm mirror with the reflective surface facing the unaffected limb was positioned vertically between the upper limbs on the table. Patients were instructed to watch how the upper limb on the uninjured side moved while imagining the motion of the limb on the affected side to be the same as that seen on the unaffected side, and completed six movements: forward flexion of the shoulder joint, flexion and extension of the elbow joint, forward and backward rotation of forearm, flexion and extension of the wrist joint, extension of the fingers and gripping, and abduction of the thumb. The participants were instructed to do each movement for five minutes while attempting to move their joints as far as they could move. Training was performed for 30 minutes each day. Sessions were 3 days a week. Each session continued for 30 minutes each day.

DATA COLLECTION

Ethical committee approval was obtained prior to the commencement of study. Three evolutions was done for functional assessment of the upper extremity by using the Fugl-Meyer Assessment Scale for upper extremity, Motor assessment scale used for motor functions assessment and Revised Nottingham assessment scale for assessment of sensory component of upper extremity.

Fugl-Meyer Upper Extremity Assessment

FMUE Scale is a strongly advised performance-based assessment of disability following stroke. It is used to evaluate the upper extremity's motor function.

Nottingham sensory assessment

In clinical studies involving stroke patients, NSA is used to evaluate the efficacy of various therapies. It is used to assess tactile perception, kinesthesia, and stereognosis.

Motor assessment scale

The purpose of this scale is to evaluate the functional recovery after a stroke or other neurological impairment. There are nine portions in it. If the patient performs better on the effected side, the higher will be the score.

Randomization: Non-probability convenient sampling method was accomplished. Patients were assigned to two groups depending upon their availability and willingness to participate in study.

Blindness: Post treatment data was collected blinded not informing patient about the assigned group. Assessor was also blind about treatment protocol given to patients.

Data analysis: Data were not normally distributed when Shapiro–Wilk test was applied. Non- parametric tests were used for analysis of within-group and between-group, by using Freidman ANOVA and Mann-Whitney U test respectively. Wilcoxon Signed rank applied to compare the pre and post values within same group. Spearman's rho applied to check correlation between all variables. SPSS version 21 was used for analysis. Mean± Standard Deviation, frequencies and percentages by using Descriptive analysis for demographic characteristics of patients.

RESULTS

Demographics and clinical characteristics of patients

Study period was completed by all patients who were participated in the study. 53.86±3.48 was the mean age and standard deviation of patients for joint integrity exercises group while 52.36±4.81 for mirror therapy group. The mean BMI was 26.32±4.29 and 25.24±1.89 for joint integrity exercises and mirror therapy group respectively. The study included 18 females and 10 males out of which 10 (71.43%) females and 4 (28.57%) males were included in joint integrity exercises group while in mirror therapy group, 8 (57.14%) females and 6 (42.86%) males were included. All types of stroke patients involved in this study. In joint integrity exercises group, 10 (71.43%) patients suffering from ischemic stroke and 4 (28.57 %) were suffering from hemorrhagic stroke. While in mirror therapy group, 8 (57.14%) were suffering from ischemic, 4 (28.57%) from hemorrhagic and 2 (14.29%) from minor stroke.

Mann-Whitney U test for between the groups comparison

According to these results, both techniques are effective but in different ways. Results of FMA sensations and RNSA with P-value less than 0.05 showed joint integrity exercises are more effective on sensory component of upper extremity. Graphical representation of MAS scores showed mirror therapy more effective on motor component of upper extremity while the statistical value of post FMA.Wrist.B (P-value=.014) showed joint integrity exercises improved the motor activity of wrist joint. Post treatment P-value (.060) of FMA passive joint motion and joint pain showed both treatments were equally effective to improve passive joint motion and joint pain of upper extremity.

Within group comparison by Friedman ANOVA Test:

Friedman ANOVA Test is used to check the effectiveness of treatment within the same group As P-value is .000 which is less than .05, shows there is statistically significant difference between three conditions (Pre, Mid, Post) within the same group, which indicates gradual improvement within group at baseline, 3 weeks and 6 weeks readings.

Table 1 Comparison of two different conditions (pre and post readings) within same group by using Wilcoxon Signed Rank Test

Variables FMA.U.E	Group A Mean±SD	Group B Mean±SD	P-value Asymp. Sig. (2-tailed)
Pre FMA.U.E.A	6.42±8.35	7.14±5.61	.083
Mid FMA.U.E.A	11.5±8.43	10.21±8.29	.816
Post FMA.U.E.A	16.5±8.45	16.21±6.88	1.000
Pre FMA.Wrist.B	1.42±2.34	.000±.000	.072
Mid FMA.Wrist.B	4.50±1.60	2.35±2.27	.028
Post FMA.Wrist.B	6.50±2.21	4.85±3.63	.014
Pre FMA.Hand.C	3.00±3.59	3.85±4.01	.804
Mid FMA.Hand.C	5.85±3.15	5.64±3.56	.334
Post FMA.Hand.C	7.78±2.63	7.07±2.75	.302
Pre FMA.Coordination.Speed.D	1.14±1.46	1.50±1.78	.673
Mid FMA.Coordination.Speed.D	2.64±1.49	3.14±1.35	.312
Post FMA.Coordination.Speed.D	4.35±1.59	3.85±1.23	.306
Pre FMA.GMF.AtoD	12.71±15.86	12.5±9.80	.368
Mid FMA.GMF.AtoD	24.57±13.17	21.00±12.83	.490
Post FMA.GMF.AtoD	35.8±13.09	32.00±10.39	.518
Pre FMA.Sensation.H	2.57±3.08	3.14±3.00	.688
Mid FMA.Sensation.H	5.71±2.81	4.57±2.87	.307
Post FMA.Sensation.H	8.57±2.76	7.42±2.13	.037
Pre FMA.PJM.JointPain.J	24.57±16.48	27.14±14.15	.853
Mid FMA.PJM.JointPain.J	30.00±13.54	36.00±11.47	.330
Post FMA.PJM.JointPain.J	35.42±11.62	44.00±5.43	.060
Variables RNSA	**Group A Mean±SD**	**Group B Mean±SD**	**P-value Asymp. Sig. (2-tailed)**
Pre RNSA.TectileSensation	54.57±12.38	53.28±12.01	1.000
Mid RNSA.TectileSensation	63.00±10.03	62.28±8.33	.853
Post RNSA.TectileSensation	70.28±8.55	69.42±5.04	.852
Pre RNSA.Proprioception	1.85±1.99	1.42±1.83	.572
Mid RNSA.Proprioception	4.21±1.67	3.57±1.39	.164
Post RNSA.Proprioception	7.07±1.59	4.57±1.22	.000
Pre RNSA.Stereognosis	2.57±2.68	2.64±3.17	.899
Mid RNSA.Stereognosis	5.21±2.19	4.28±3.03	.453
Post RNSA.Stereognosis	8.21±2.29	6.78±1.96	.031
Pre Gross RNSA	59.00±15.86	57.71±15.85	1.000
Mid Gross RNSA	72.42±10.8	70.14±11.58	.662
Post Gross RNSA	84.50±10.8	80.78±6.87	.034

Wilcoxon Signed Rank Test is used to check the differences between Pre and Post readings within the same group. Results of Wilcoxon Signed Rank Test showed there are statistically significant differences between the pre and post readings within same group because P-value is less than .05 whereas negative Z- value indicate negative ranks. As P-value statistically more significant. Z-value will be more negative. (Table 1)

Table 2 Correlation of FMA. U.E with RNSA, FMA. U. E with MAS and RNSA with MAS

Variables MAS	Group A Mean±SD	Group B Mean±SD	P-value Asymp. Sig. (2-tailed)
Pre-Gross MAS	7.42±5.48	6.71±5.25	.852
Mid Gross MAS	9.78±6.02	10.50±4.76	.459
Post Gross MAS	12.8±7.53	15.28±4.98	.230

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Figure 1: Improvement of motor component in upper limb measured by Fugl-Meyer upper extremity in both groups.

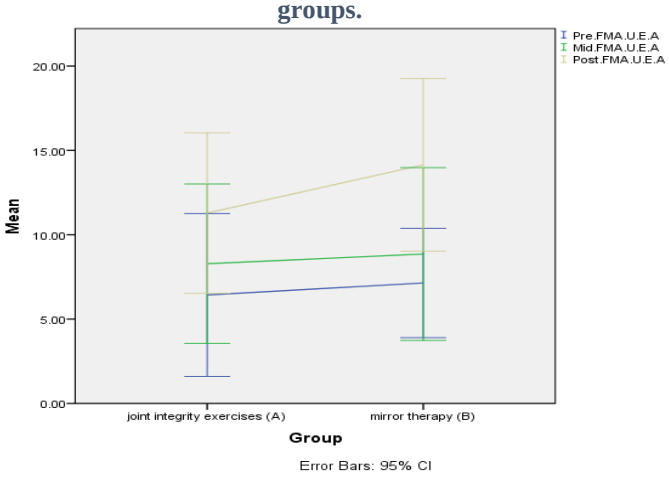

Figure shows the improvement of motor component in upper limb measured by Fugl-Meyer upper extremity in both groups. Results of correlation of FMA with RNSA, FMA with MAS and RNSA with MAS showed that sensory and motor components of upper extremity were positively correlated with each other, which means in hemineglect stroke survivals, improvement in sensory component i-e proprioception can be helpful to improve functional rehabilitation of patients and vice versa.

DISCUSSION

Joint integrity exercises showed statistically significant results when improvement checked at wrist joint by using Fugl Meyer. In stroke patients, task oriented activities dramatically enhance motor function, hand coordination and fine motor skills.(24) Previous literature suggests that recovery of movement occurs first in shoulder, then elbow and at the end at wrist in stroke patients. This pattern of improvement shows proximal to distal recovery.(25)

Pre and post value of MAS score indicated mirror therapy was more effective showing the improvement in the motor component in upper extremity. Neuroplasticity is the process through which healing occur in upper extremity. But this process is slow, due to which recovery of upper extremity is slow in stroke patients. Mirror therapy helps to speed up the process of neuroplasticity through repetitions of single movement and visual feedback (26) Findings of previous study demonstrate that mirror therapy effectively enhances daily functioning skills in stroke patients with unilateral neglect.(27) On the other hand, a study suggested that with isometric training, mirror treatment did not improve the cross-education impact in stroke patients stroke ($P > 0.05$).(28)

P-value of passive joint motion and joint pain measured by Fugl Meyer showed there was no statistically significant difference between the effectiveness of both treatment methods. Previous study showed that mirror therapy significantly reduced pain compared to other methods i.e one tactile stimuli, four covered mirrors, one phantom exercise, three mental visualization exercises, one sensorimotor exercise, one transcutaneous electrical nerve stimulation.(29)

P-value of post-treatment improvement measured by Fugl Meyer at wrist joint showed that joint integrity exercises were helpful to improve motor component of upper extremity. Findings of a study showed that in stroke patients, sensory afferent input from peripheral nerves enhances the neuronal function of the sensorimotor cortex, thus enhance both sensory and motor function of patients. Motor related cortical activation is improved and related brain patterns are more discriminative with the right sensory stimulus.(30) Tactile stimulation helps to improve motor function of stroke patients.(31)

Wrist joint motor activity improved in patients of joint integrity exercises group. While according to research, in individuals with sensorimotor deficits in the early stages of post-stroke rehabilitation, upper limb motor therapy may improve motor impairment more than upper limb sensorimotor therapy. Sensorimotor therapy may be less successful for these individuals' motor recovery and somatosensory function improvement.(32)

Sensory components measured by RNSA and sensations component (H) of Fugl Meyer showed joint integrity exercises were more effective for enhancing sensory functions than mirror therapy. Mechanosensory withdrawal thresholds significantly and almost entirely recovered after vagus nerve stimulation was combined with tactile rehabilitation. Rehabilitation with tactile stimulation without VNS was unsuccessful in enhancing sensory function.(33)

Reading of spearmen's rho results between values measured by Fugl Meyer and RNSA showed positive correlation between sensory and motor components of upper extremity. A study shows significant correlation between proprioception and motor dysfunction after stroke. Proprioceptive stimulation helps in improving upper limb function mobility in stroke patients.(34) Proprioception issues and decreased motor recovery have a well-established relationship.(35)

Motor component of upper extremity measured by Fugl Meyer and MAS showed more improvement by mirror therapy than joint integrity exercises. A study indicates that mirror therapy is advantageous in the field of stroke recovery and functional rehabilitation in hemineglect stroke patients.(36) According to a study, When mirror therapy paired with conventional hand paresis rehabilitation twice a week for five weeks, mirror therapy enhances upper limb motor recovery and level of independence in self-care after stroke.(37)

Improvement in function of wrist joint by applying joint integrity exercises showed sensory stimuli can improve upper extremity motor functions. The activation of the autonomic nerve system, which properly controls finger movements, can be influenced by sensory stimuli. Kinesthetic stimulation and thermal stimuli helped in the improvement of function of hand.(38)

This study has few limitations like small sample size, lack of long term follows up, loss of interest of patients with the passage of time and the study is double blinded.

CONCLUSION

Joint integrity exercises are more effective on sensory components of upper extremity than mirror therapy and proprioception and functional rehabilitation of upper limb are positively correlated with each other which means in hemineglect stroke survivals, improvement in sensory component i-e proprioception can be helpful to improve functional rehabilitation of patients and vice versa. By using these interventions as treatment protocl, sensory and motor

skills of patients can be enhanced. This study provides a wide area for researcher to work on chronic stroke patients with long term interventions and follow up of patients. By providing economical facilities to researchers and patients, this study can be done more precisely and proficiently.

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CONFLICT OF INTEREST

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DATA SHARING STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request

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