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The efficacy of mirror therapy vs tactile stimulation to increase upper limb dysfunction in patients with chronic stroke: A comparative study

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Abstract
Background and Purpose: Mirror therapy has been recommended as a simple, inexpensive approach to upper limb dysfunction and tactile stimulation used to increase the motor execution system in order to enhance voluntary activation of muscle. To compare the effects of Mirror therapy vs tactile stimulation to increase upper limb function in chronic stroke patients.
Type of the study: Quasi Experimental Study Design.
Materials and Methodology: A sample of 30 patients within the age group of 40 to 60 years of chronic stroke patients with upper limb dysfunction were randomly divided into two groups. Group A (n=15) and Group B (n=15). The subjects in the group A is treated with Mirror therapy and the subjects in the group B is treated by tactile stimulation. The subjects were assessed by Action Research Arm Test and Motricity Index scale before and after completion of 6 weeks treatment program.
Result: After 6 weeks of treatment there is significant difference between both Group A and Group B but there is more improvement noticed in Group A in compared to Group B.
Conclusion: Mirror therapy was more effective in improving the upper limb function in chronic stroke patients.

Keywords: Mirror therapy, upper limb dysfunction, tactile stimulation, stroke

Introduction
Stroke or brain attack is the sudden loss of neurological function caused by interruption of blood flow to the brain. Stroke is a major cause of limitations in the everyday activities of patients often leading to dependency on long term care in recovery of upper limb function is challenging. Currently there is limited evidence that specific treatment methods are more effective than others. Upper limb dysfunction is a leading cause of loss of independence in stroke survivors. Rehabilitation for the hemiplegic Upper limb is frequently short term and limited by resources.
Principle of mirror therapy is simple when looking into the mirror, the patient observes the reflection of the unaffected limb positioned as the affected limb. When performing motor or sensory exercises with the non-affected limb, the reflection in the mirror is often perceived as the affected, paretic limb. This strong visual cue from the mirror can therapeutically be used to improve motor performance and the perception of the affected limb. Recently a Cochrane review wad published that indicated evidence for the effectiveness of mirror therapy in improving upper limb motor function in stroke patients.
Tactile stimulation is a module of routine therapy currently used in clinical practice to treat the upper limb after stroke. Tactile Stimulation involves hands on sensorimotor stimulation to the forearm and hand.

Epidemiology
Stroke is the second frequent cause of death worldwide, accounting for 6.2 million deaths. In the United States approximately 800,000 people sustain a stroke each year and nearly 400,000 survive with some level of neurological impairment and disability. A stroke happens every 40 seconds and each 4 min someone dies from stroke. The risk of stroke is increased from 35 years and 95% of stroke is occur in people age of 45 years and two-third of stroke occur over 65 years.

Males are 25% more likely to suffer strokes than women, yet 60% of death from stroke is occur from women.

Classification

Stroke can be classified onto two major categories: ischemic and hemorrhagic. Ischemic are caused by interruption of the blood supply to the brain, while the hemorrhagic strokes result from the rupture of a blood vessel or an abnormal vascular structure. About 87% of strokes are ischemic, the rest being hemorrhagic. Bleeding can develop inside areas of ischemia, a condition known as "Hemorrhagic transformation". It is unknown how many hemorrhagic strokes start as ischemic stroke.

Risk factors

A) Modifiable risk factors

- Hypertension – 70%
- Heart disease – 30%
- Congestive heart failure -- 15%
- Peripheral arterial disease – 30%
- Physical activity
- Obesity
- Diet

B) Nonmodifiable risk factors

- Heredity
- Age
- Gender

Anatomy of blood supply to brain

- The head and brain receive its arterial blood supply via the carotid artery which originates from the arch aorta. At the base of the ear the carotid artery branches into internal and external branches, the external carotid artery supplies the face scalp, skull and meninges. An important branch is the middle meningeal artery, laceration of the artery in the temporal area may cause an epidural hematoma.
- The internal carotid artery supplies the brain itself. It is commonly divided into its intracranial part which consists of carotid siphon which transverse the base of the skull and its extracranial part which branches into the middle cerebral, anterior cerebral, and posterior cerebral arteries to form the circle of Willis
- The anterior cerebral artery supplies the frontal lobes and medial aspects of the parietal and occipital lobes.
- The middle cerebral artery also called as the artery of stroke, supplies the frontoparietal somatosensory cortex. Infracts in its terrioty result in contralateral hemiparesis.
- The posterior cerebral artery supplies the occipital and inferior temporal lobe including the hippocampus.
- The circle of Willis consists of the anterior and posterior communicating arteries, striate arteries also known as "penetrators" branch from the circle of Willis to supply the basal ganglia and thalamus. These vessels are common source of strokes. Both small ischemic infracts, known pathologically as lacunas and major intracerebral hemorrhages occur within the tissue supplied by these penetrating arteries.
- The medulla is supplied by the vertebral arteries. The anterior spinal artery arises at the bifurcation of the vertebra and descends to supply the spinal cord.
- The vertebral artery fuses at the pontomedullary junction to form the caudal aspect of the basilar artery. Penetrates from then basilar artery supply the pons. The superior cerebellar artery superiorly from the basilar artery. The basilar artery the bifurcates into the posterior cerebellar arteries.
- Large veins in the subarachnoid space empty in the Dural venous sinuses. The sagittal sinus is located in the dura within the longitudinal fissure. The vein of the Galen is a medial and rostral extension of the transverse sinus in the tentorium.

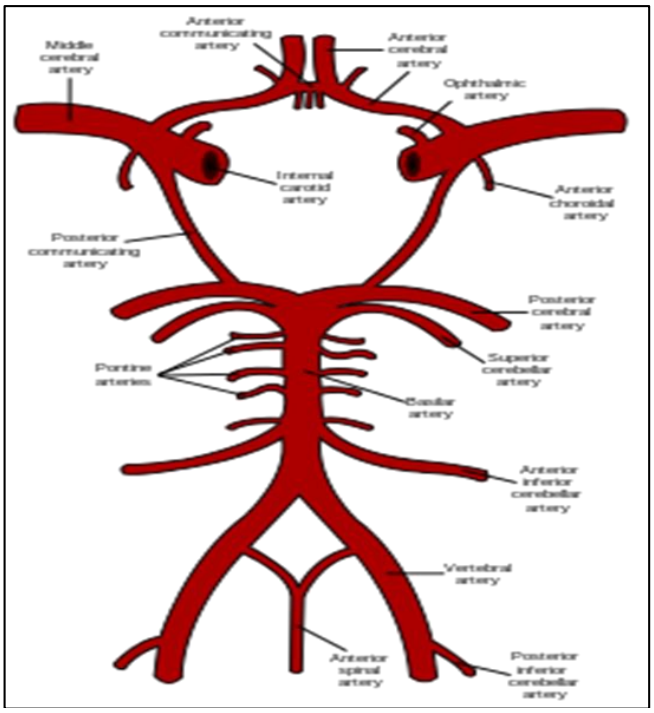

Fig 1: Blood supply of brain

Physiology

Interruption of blood flow only for few minutes sets in motion in a series of path neurological events. Complete cerebral circulatory arrest in irreversible cellular damage with a care of focal interaction**.** The area surrounding the core is termed as ischemic penumbra and consists of variable but metabolically lethargic cells the ischemia triggers a number of damaging and potentially reversible events the release of cascade of chemicals. The release of excess glutamates and excitatory neurotransmitters cause changes in calcium iron distribution with the activation of destructive enzyme. The overall effect is one additional neural death generally within hours and extension of interaction into penumbra.

Clinical features

Anterior cerebral artery syndrome

- Contralateral hemiparesis
- Sensory loss of foot and leg
- Contralateral lateral grasp reflex
- Sucking reflex
- Urinary incontinence
- Frontal tremor
- Apraxia
- Para tonic rigidity
- Cerebral paraplegia

Middle cerebral artery syndrome
- Ataxic hemiparesis
- Germstann syndrome
- Homonymous hemianopia
- Limb kinetic apraxia
- Anosognosia
- Unilateral neglect
- Pure motor hemiplegia
- Speech impairments
- Perceptual deficits

Posterior cerebral artery syndrome
- Thalamic syndrome
- Ataxia
- Tremor
- Astimultagnosia
- Visual defects
- Nystagmus
- Alexia without agraphia
- Contralateral hemiparesis
- Contralateral hemihypersethesia
- Memory defect

Impairments
Stroke results in some structural and functional alterations, which termed as impairments. They may be primary or secondary**.**

Primary impairments
- Sensory deficits
- Pain
- Visual defects
- Altered muscle tone
- Weakness
- Balance disorder
- Speech disorder
- Swallowing difficulties
- Perceptual dysfunction
- Emotional disturbances
- Seizures bladder and bowel dysfunction

Secondary impairments
- Venous thrombo embolism
- Skin breakdown
- Decreased flexibility of joints
- Shoulder subluxation
- Reflex sympathetic dystrophy

Factors of weakness
- Impaired force magnitude
- Slowness to produce movement
- Rapid onset of fatigue
- Excessive sense of effort

Operational definitions
Stroke
Rapidly developed clinical signs of focal or global disturbance of cerebral function lasting more than 24 hours or leading to death with50 apparent cause other than vascular origin.

WHO upper limb dysfunction
Upper limb dysfunction is a common functional impairment after a stoke.it is direct consequence of the lack of signal transmission from the motor cortex after stroke. This transmission generates the movement impulse to the spinal cord which executes the movement via signals to muscles. Such lack of transmission after stroke results in delayed initiation, delayed transmission of muscle contraction and slowness in developing force. This is manifested as limbs inability to move or move quickly. -Susan M. Hunter

Tactile Stimulation
Tactile stimulation includes the activating of nerve signals beneath the skin's surface that inform the body of texture, temperature and other touch-sensations. -Jacqueline M. Winter

Mirror Therapy
Mirror therapy is the use of a mirror to create a reflective illusion of an affected limb in order to trick the brain into thickening movement has occurred without pain.it involves placing the affected limb behind a mirror, which is sited so the reflection of the opposing limb appears in the place of hidden limb. - VS Ramachandran

Need for the study
Stroke is a second leading cause for death. Mostly stroke patients are having difficulty in using their arm and hand and also difficulties in performing ADL activities for their daily living.

Aim of the study
To find out the effectiveness mirror therapy vs tactile stimulation for upper extremity to improve upper limb function in chronic stroke patients.

Objectives of the study
- To have a depth knowledge on hemiplegic upper extremity.
- To know Mirror therapy and tactile stimulation.
- To assess the efficacy of Mirror therapy and tactile stimulation.
- To increase the functions of the upper extremity.

Variables of the study
A) Independent Variables
- Mirror therapy
- Tactile stimulation

B) Dependent variables
- Action Research Arm Test Scale.
- Motricity Index Arm Test.

Hypothesis
A) Null hypothesis
It makes the research to be performed with in the premises of null hypothesis which started as follows:
“There is no significant improvement in upper limb functions following Mirror therapy vs Tactile stimulation”.

B) Alternative hypothesis
It makes the research to be performed with in the premises of alternative hypothesis which stated as follows:
“There is significant improvement in upperlimb functions following Mirror therapy vs Tactile stimulation”.

Materials
The following materials were used in the study in which Mirror therapy and Tactile stimulation was given for the stroke patients.

- Couch
- Pillow arm rest chair
- Knee hammer
- Talcum or baby powder
- Lock and key
- Ice
- Comb
- Towel
- Plinth or mat
- Pillows
- Temperature stimuli (warm and cold)
- Wooden cubes
- Smiley ball
- Pen
- Tumbler
- Mirror
- Table
- Large chairs

Methodology
All the patients underwent a general neurological examination and upper limb evaluation.

Population
Chronic stroke survivors of age 40 to 60 years old.

Study design
The design used for the study is Quasi experimental study Pre and post experimental design.

Study setting
RKR Neuro Specialty Hospital, Erode.
Government Headquarters Hospital, Erode.

Subjects
30 Stroke Patients.

Study duration
Study was conducted for a period of 12 months.

Treatment duration
Monday to Friday for 6 weeks – mirror therapy with conventional physiotherapy and tactile stimulation with conventional physiotherapy.

Study sampling
Convenient Sampling Method.

Sampling size
A total of 30 stroke patients.
Group A – 15 patients
Group B – 15 patients

Criteria for sample selection
30 subjects of stroke patients.

Inclusive criteria
Adult stroke survivors, Men and Women 40 to 60 years older (no upper age limit).

1) Contralesional Upper limb dysfunction of at least 12 months duration.
2) Had been discharged from ongoing therapy.
3) Able to follow a simple command using the nonparetic upper limb (e.g. place your hand on your head).
4) Willingness to participate.
5) No visual perceptual, communication problem.
6) Suggest sufficient cognitive and communication ability to understand.

B. Exclusive criteria

1) Upper limb dysfunction caused by other pathological disorders unrelated to stroke.
2) E.g. Musculoskeletal disorders of the shoulder girdle.
3) Painful or subluxed shoulder.
4) Uncooperative patients.

Parameters
Motricity Index Arm Section
Action Research Arm Test

Procedure
Technique and application
Patients in and around Erode were participated in the study. Patients are selected based on the inclusion criteria. Detailed information regarding the study was given and informed consent was taken. 30 participants are divided into 2 groups namely Group A and Group B.

- Group A received Mirror therapy.
- Group B received Tactile stimulation.
- Both Group A and Group B received Conventional physiotherapy.

Treatment was given 1 hour per day for 6 weeks (monday to friday

Group A (Mirror therapy)
The dimension of the mirror should be big enough to cover the entire affected limb and should allow patients to see all major movements in the mirror. A size of 25 x 20 inches for the upper limb.

Position of affected limb
The affected limb should be positioned on a table. The affected limb is situated in a safe and preferably comfortable position behind the mirror.

Position of non-affected limb
The patient should try to facilitate a vivid “mirror illusion” (Mirror image perceived as the affected limb) by matching the position and image of the non-affected limb to the affected side. For example, the non-affected limb should be positioned in a similar position as the affected limb, as this facilitates the intensity of the mirror illusion.

Fig 2: Mirror therapy

Position of the mirror
Generally, the mirror is positioned in front of the patient's midline, so that the affected limb is fully covered by the mirror and the reflection of the unaffected limb is completely visible. The important point when adjusting the position of the mirror is to assure that the mirror image still matches with the perception of the affected limb.
Over the first two to three weeks, therapists generally start with simple exercises like flexion and extension movements of the fingers, wrist and elbow. This is also the case in patients with a flaccid limb. In principle all degrees of freedom of the joints may be addressed. Most common is to start with the range of motion that can also be achieved in the affected side, slowly increasing the range and the complexity of the movements ("shaping"). Remember to apply the basic principles of motor learning: a high number of repetitions combined with variation of the movement performance.

Using functional task
The functional tasks with different objects (e.g. cups, wooden blocks or balls) are integrated into the treatment program.

Group B (Tactile stimulation)
Tactile stimulation: Session begins with the

1) Proprioceptive neuromuscular facilitation such as
- Quick stretch
- Prolonged stretch
- Resistance
- Joint traction
- Inhibitory pressure.

2) Cutaneous stimulation techniques such as
- Manual contacts
- Light touch
- Maintained touch
- Slow stroking
- Neutral warmth
- Prolonged icing.

Group A and Group B – Conventional Physiotherapy
- Range of motion exercises
  - Passive movements,
  - Stretching,
  - Active movements.
- Weight bearing exercises
- Shoulder shrugs
- Vestibular exercises
- Scapular movements

Technique
Starting position: Patient concentration the pattern of movement and effort required to perform it.

Pattern of movement: Show the demo to the patient by therapist

Fixation: Fixation should be achieved by active means in order that the weak muscles may receive reinforcement from the action of those muscles with which they normally associate for the production of voluntary movement.

Support: The support provided by the physiotherapist hand suspension slings, re- education board, buoyancy of water or ball bearing skates.

Traction: Preliminary stretching of the weak muscles to elicit myotatic reflex provides stimulus to contraction.

Assisting force: By means of physiotherapist hands placed in the surface of patient skin in the direction of the movement at rest.

Repetition: Based on the capacity of the patient, repetition will be followed.

Co-operation of the patient: Concentrated effort, type of exercise can to help the movement and encouraged to palpate his muscles as they contract.

Data presentation and statistical analysis
Statistical analysis: The statistical tools used in the study are paired t -- test and unpaired t – test.

a) Paired 't' - Test
The paired t – test was used to find out the statiscal significance between pre and post t – test values of Mirror Therapy and Tactile Stimulation before and after treatment for Group A and Group B.
Formula for paired t – test,

$$S = \frac{\Sigma d^2 - \frac{(\Sigma d)^2}{n}}{n-1}$$

$$t = \frac{\bar{d}\sqrt{n}}{s}$$

d = difference between the pre-test post test
$\bar{d}$= mean difference
n = total number of subjects
S = Standard deviation

b) Unpaired t – test
The unpaired t-test was used to compare the effects between two groups, students't' test for unpaired values.
Formula unpaired t –test.

$$S = \sqrt{\frac{(n_1-1)s_1^2+(n_2-1)s_2^2}{n_1+n_2-2}}$$

$$t = \frac{|\bar{x}_1 - \bar{x}_2|}{s\sqrt{\frac{1}{n_1} + \frac{1}{n2}}}$$

n_1= total number of subjects in Group – A
n_2=Total number of subjects in Group – B
$\overline{X_1}$ =Mean difference between pre test and post test of Group -- A
$\bar{x}_2$=Mean difference between pre test and post test of Group – B
S = Difference between pretest and posttest of Group -- A
S_2 = Difference between pretest and posttest of Group – B

Data presentation

Table 1: mean difference value of group A and group B Motricity index and action research arm test

Group	Mean Difference	
	Motricity index	Action research arm test
Group A	19	38
Group B	16	33

Mean difference of group A and group B

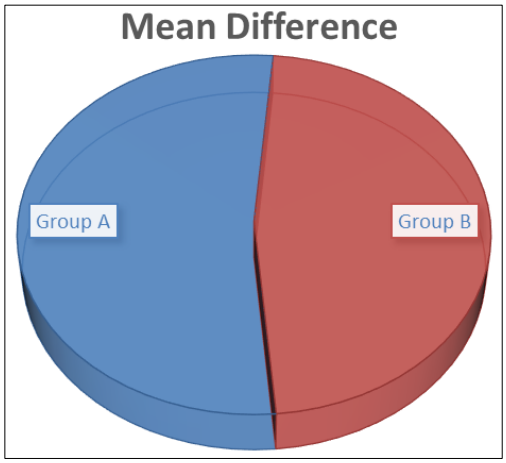

Fig 3: Motricity Index

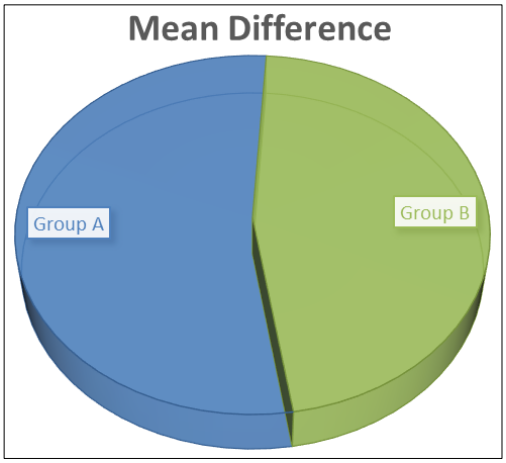

Fig 4: Action Research Arm Test

Table 2: Standard deviation values of group A and group B (Motricity index and action research arm test)

Group	Standered deviation	
	Motricity index	Action research arm test
Group A	2.1	2.97
Group B	1.94	2.91

Standard deviation of Group A and Group B

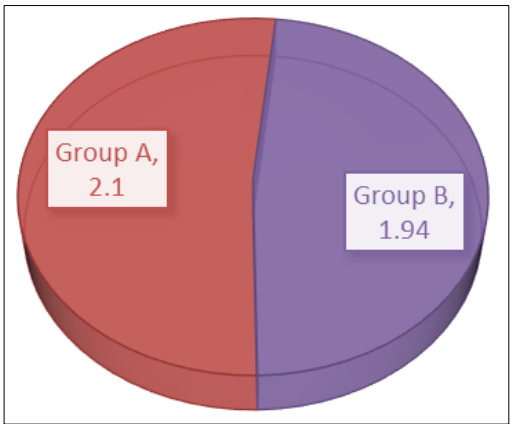

Fig 5: Motricity Index

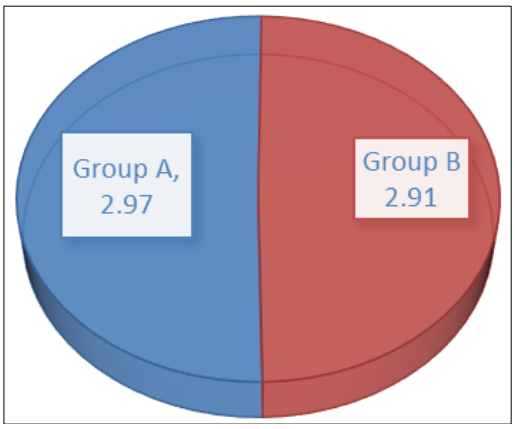

Fig 6: Action Reaserch Arm Test

Table 3: Paired‘t’ test value of group a and group b (motricity index scale and action research arm test)

Groups	Calculated Paired ‘t’ Values		Table value	Significance
	MI	ARAT		
Group A	35.01	49.49	2.15	Significant
Group B	31.91	43.91	2.15	Significant

Paired 'T' Test of Group A and Group B

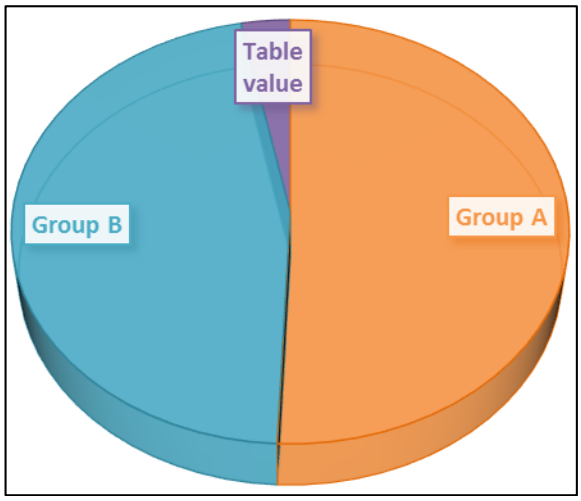

Fig 7: Motricity Index

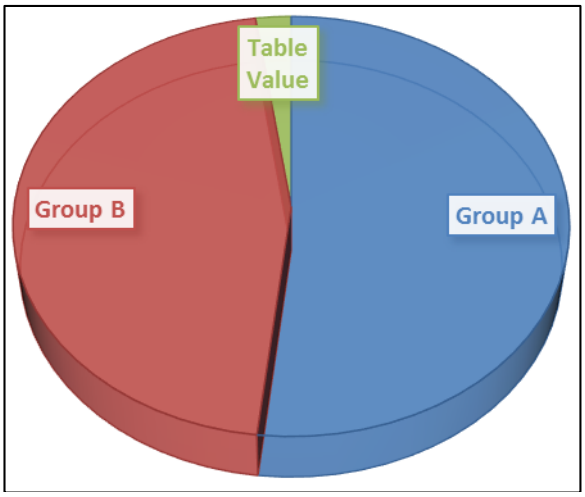

Fig 8: Action Research Arm Test

Table 4: Unpaired 't' test value of group A and group B Motricity index and action research arm test

Groups	calculated unpaired 't' values		Table value	Significance
	MI	ARAT		
Comparison of group A and group B	4.16	4.76	2.05	Significant

Unpaired 't' test value of the group A and the group B

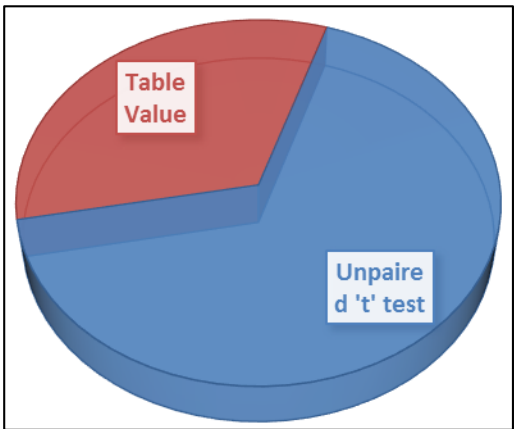

Fig 9: Motricity index

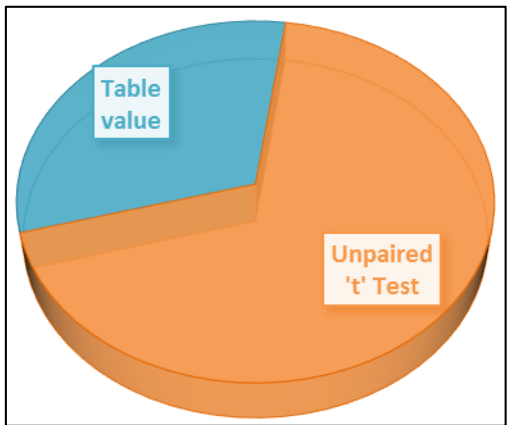

Fig 10: Action research ARM test

Result and Discussion

Results

The study sample comprised of 30 patients, of which 15 were group A and group B. All the subjects underwent neurological assessment Performa. The median time interval applied between before and after therapy was 6 weeks. Among 30 patients, 15 were treated with Mirror therapy and 15 were treated with Tactile stimulation.

The pre and posttest values were assessed by MI and ARAT motor and sensory function test in Group A. The mean difference value is 19 and 38 respectively. The standard deviation value is 2.10 and 2.97 respectively. The paired 't' test value for MI and ARAT is 35.01 and 49.49. The paired value is more than table value 2.15 for 5 % level of significance at 14 degrees of freedom.

The pre and post-test values were assessed by MI and ARAT motor and sensory function test in Group B. the mean difference value is 16 and 33 respectively. The standard deviation value is 1.94 and 2.91 respectively. The paired't' test value for MI and ARAT is 31.91 and 43.91. The paired 't' test value is more than table value 2.15 for 5 % level of significance at 14 degrees of freedom.

The calculated 't' values by unpaired 't' were 4.16 and4.76. the calculated 't' values were more than table value 2.05 for 5 % level of significance at 14 degrees of freedom.

The paired 't' values have shows mirror therapy program were more effective than MTS for patients with stroke. The unpaired 't' test values have shown that there was significant difference between two groups in improvement in their quality of life in patients with stroke.

Discussion

The rehabilitation of the stroke is a challengeable task. Many therapeutic approaches are currently available. For this purpose, 30 stroke patients were recruited and divided into group A and group B.

First group was assigned as group A which comprised 15 patients and received Mirror therapy and the second group the group B and received Tactile Stimulation. The results from the recorded Measurements proved that the Mirror

therapy were more effective than the group treated with Tactile stimulation in stroke.

According to Park JY *et al* mirror therapy is effective in improving paretic upper extremity function and activities of daily living.

According to Ezendam *et al* these mirror therapy has significally improved the quality of stroke patients Improve more affected upper extremity in the activities of daily living in life situation.

According to Mirelacristina improvement of motor functions, manual skills and activities of daily living. The best results were obtained when the treatment was started early after stroke. Mirror therapy is an easy and low-cost method to improve recovery of the upper limb.

The final stage of my thesis work found that mirror therapy not only improves the sensorimotor function and also to reverse the learned non-use of stroke patient.

Limitations of the study

- This study has been conducted on small size sample only.
- This study has taken more time to complete.
- Variation in climate, drugs, diet, personal habit, side of involvement, gender, age could not be controlled.

Recommendations

- A similar may be extended with larger samples.
- Mirror therapy may be applied to the other conditions like cerebral palsy, traumatic brain injury, spinal cord injury.
- A similar study may be extended to infantile stroke patients also.

Summary and Conclusion

From the result of this study through mirror therapy shows improvement for the recovery of the upper limb functions after stroke, mirror therapy has more advantages over Tactile stimulation in terms of reverse the learned nonuse and upper limb function. Clinically it is important after stroke to regain the sufficient upper limb function.

Based on 't' values, it could be seen there is significant difference between the calculated values and table values. The mean and standard deviation between these groups show greater from Mirror therapy than tactile stimulation.

Through the results, alternative hypothesis is accepted and also the study should be concluded that there is significant effect of mirror therapy on upper extremity functions in stroke patients.

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