Original Article

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Intermittent Pneumatic Compression and Mirror Therapy Improve Hand Functions after Stroke

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Abstract

Introduction: A stroke is a clinical syndrome characterized by rapidly developing clinical symptoms and/or signs of focal, and at times global (applied to patients in deep coma and those with subarachnoid haemorrhage), loss of cerebral function, with symptoms lasting more than 24 hours or leading to death, with no apparent cause other than that of vascular origin (Hatano, 1976) [1]. *Need for Study:* To compare two treatment protocols to improve hand functions in sub-acute stroke subjects. *Methods:* It is an experimental study design. Sample of convenience of thirty sub-acute stoke subjects are selected and divided into group A and group B. Group A receive Intermittent Pneumatic Compression combine with Mirror Therapy for their hemiplegic upper limb. Intermittent Pneumatic Compression is given for 30 minutes a day, 6 days a week for 4 weeks and Mirror Therapy is given for two hours a day, 6 days a week for 4 weeks. Group B receives ROM exercises, stretching; strengthen exercises for 60 minutes/day, 6 days a week for 4 weeks. *Discussion*: Clinical Test for sensation (NSA), motor function (Brunstrom Motor Recovery Stages) and FIMS was used in this study to determine hand functions improved by Intermittent Pneumatic Compression and Mirror Therapy. The results obtained revealed interesting findings in sub-acute stroke subjects. Sensory as well as motor function improved by Intermittent Pneumatic Compression and Mirror Therapy. Sensory impairment is improved by Intermittent Pneumatic Compression. *Conclusion*: The study concluded that hand functions improved by Intermittent Pneumatic Compression and Mirror Therapy in sub-acute stroke subjects and interventions should be emphasize to restore motor and sensory function.

Keywords: Intermittent pneumatic Compression machine; Mirror (35x35cms); Plinth, Stepper; Table & Pillow.

Introduction

A stroke is a clinical syndrome characterized by rapidly developing clinical symptoms and/or signs of focal, and at times global (applied to patients in deep coma and those with subarachnoid haemorrhage), loss of cerebral function, with symptoms lasting more than 24 hours or leading to death, with no apparent cause other than that of vascular origin (Hatano, 1976) [1].

Stroke is the leading cause of disability and the third or fourth leading cause of death both in the USA and many developed countries around the world. The most common deficit after stroke is hemi paresis of the contra lateral upper limb [1].

Stroke survivors were found to have impairments in force control, fine motor manipulation of objects, sensory ataxia, decreased grasp, and changes in prehension patterns, all of which have been found to be associated with sensory impairment [2].

The development of secondary complications such as sores, abrasions, and shoulder-hand syndrome has been associated with the impairment of sensation. Sensory impairment has also been found to be directly associated with the development of shoulder pain and subluxation [3].

Previous studies in stroke, although undersized and not sufficiently controlled, suggested that mirror therapy may be beneficial for motor function recovery in the paretic hand [4-6].

Ramachandran and Rogers-Ramachandra were the first to introduce the use of these visual illusions created by a mirror for treatment of phantom limb pain. By superimposing the intact arm on the phantom limb using a mirror reflection, patients reported the sensation that they could move

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and relax the often-cramped phantom limb and experienced pain relief [7].

In the 1970s and 1980s Margaret Johnstone developed a neurological treatment programme using infatable pressure splints, aimed to reduce spasticity, facilitate normal movement and increase sensory input in the affected extremities on the hemiplegic side [14-15].

In this study we are combining motor and sensory interventions to know that if hand functions are improved after sub-acute stroke.

Operational Definitions

Stroke

A stroke is a clinical syndrome characterized by rapidly developing clinical symptoms and/ or signs of focal, and at times global (applied to patients in deep coma and those with subarachnoid haemorrhage), loss of cerebral function, with symptoms lasting more than 24 hours or leading to death, with no apparent cause other than that of vascular origin (Hatono, 1976) [1].

Intermittent Pneumatic Compression

Intermittent pneumatic compression is a therapeutic technique used in medical devices that includes an air pump and inflatable auxiliary sleeves, gloves or boots in a system designed to improves venous circulation in the limbs of patients who suffer edema or the risk of deep vein thrombosis (DVT) [9].

Mirror Therapy

Mirror therapy is a pioneering, non-invasive treatment for the management of chronic pain. As the term implies, the primary tool of this therapy is a mirror from which the patient receives visual feedback in order to train the brain to configure a new "body map". This so-called map is simply the hard-wired mental representation that allows a person to be aware of where each component of the body is at all times, even in complete darkness. This built-in diagram also permits on to move in complex ways without having to consciously focus on each step to perform [10].

Research Hypothesis

Experimental Hypotheis: Intermittent pneumatic compression and mirror therapy may improve hand functions after stroke.

Null Hypotheis: Intermittent pneumatic compression and mirror therapy may not improve hand functions after stroke.

Need For Study

To compare two treatment protocols to improve hand functions in subacute stroke subjects.

Aim of Study

To implement combined sensory and motor rehabilitation protocol to improve hand functions after stroke.

Review of Literature

This chapter deals with the view of literature associated with combined effects of Intermittent Pneumatic Compression and Mirror Therapy to improve hand functions in sub-acute stroke subjects. This includes the theory and effects.

(Hatona, 1976) A stroke is a clinical syndrome characterized by rapidly developing clinical symptoms and/or signs of focal, and at times global (applied to patient in deep coma and those with subarachnoid haemorrhage), loss of cerebral function, with symptoms lasting more than 24 hours or leading to death, with no apparent cause other than that of vascular origin [1].

This definition includes stroke due to cerebral infarction, primary intracerebral haemorrhage (PICH), intraventricular haemorrhage, and most cases of subarachnoid haemorrhage (SAH); it excludes subdural haemorrhage, epidural haemorrhage, or intracerebral haemorrhage (ICH) or infarction caused by infection or tumor. TIAs are brief episodes of neurological dysfunction resulting from focal cerebral ischemia not associated with permanent cerebral infarction [11].

Pathophysiology

Focal Ischemic Injury

A thrombus or an embolus can occlude a cerebral artery and cause ischemia in the affected vascular territory. At a gross tissue level, the vascular compromise leading to acute stroke is a dynamic process that evolves over time [16].

Cerebral Blood Flow

Normal cerebral blood flow (CBF) is approximately 50-to 60 l/100g/Min and varies in different parts of the brain. In response to ischemia, the cerebral auto regulatory mechanisms compensate for a reduction in CBF by local vasodilatation, opening the collaterals, and increasing the extraction of oxygen and glucose from the blood [17].

However, when the CBF is reduced to below 20ml/100g/min, an electrical silence ensues and synaptic activity is greatly diminished in an attempt to preserve energy stores. CBF of less than 10ml/100g/min results in irreversible neuronal injury [1,6-11].

Apoptotic mechanisms being within 1 hour after ischemic injury whereas CN begins by 6 hours after arterial occlusion. This observation has an important bearing on future directions of research. The manner by which apoptosis evolves is a focus of much research, because, hypothetically, neuronal death can be prevented by modifying the process of DNA cleavage that seems to be responsible for apoptosis [12].

Nudo et al. (2000) showed how motor impairment after damage to the motor cortex may at least partially be due to sensory deficit, or sensory/ motor disconnection. This is especially true for the upper limb, which is required for fine, skilled movement, and it has long been recognized that the upper limb is, in essence, useless with serious sensory impairment [13].

Intermittent Pneumatic Compression

Intermittent pneumatic compression is a therapeutic technique used in medical devices that include an air pump and inflatable auxiliary sleeves, gloves or boots in a system designed to improve venous circulation in the limbs of patients who suffer edema or the risk of deep vein thrombosis (DVT) [18].

In use, an inflatable jacket (sleeve, glove or boot) encloses the limb requiring treatment, and pressure lines are connected between the jacket and the air pump. When activated, the pump fills the air chambers of the jacket in order to pressurize the tissues in the limb, thereby forcing fluids, such as blood and lymph, out of the pressurized area. A short time later, the pressure is reduced, allowing increased blood flow back into the limb.

The devices can be categorized as either uniform pressure or sequential compression device, depending on how the pressure in the inflatable jacket is modulated [19].

In the 1970s and 1980s Margaret Johnstone developed this neurological treatment Programme. Using inflatable pressure sleeves for the extremities she aimed to reduce spasticity facilitate normal movement and increase sensory input in the affected extremities on the hemiplegic side [22].

In a next step she attempted to augment sensory input by connecting these inflatable splints to an intermittent at this stage developing sensation is influenced by three major inputs: touch, movement and pressure.

Mirror Therapy

Mirror therapy is a pioneering, non – invasive treatment for the management of chronic pain. As the term implies, the primary tool of this therapy is a mirror from which the patient receives visual feedback in order to train the brain to configure a new" body map." This so-called map is simply the hard –wired mental representation that allows a person to be aware of where each component of the body is at all times, even in compete darkness, this built-in diagram apso permits one to move in complex ways without having to consciously focus on each step to perform.

Ramachandran and Rogers-Ramchandran in 1996 first reported Mirror therapy for the treatment of phantom limb pain. In this treatment, the patient views the reflection of their intact limb moving in a mirror placed para sagittally between the arms or legs while simultaneously moving the phantom hand or foot.

The virtual limb in the mirror appears to be the missing limb. Patients have reported a relief of cramping and "frozen limb" phantom pains as a result of even one session with the mirror. The Efficacy of mirror therapy was reported to be 60% (9/15 upper limb amputees) [7].

Altschuler et al. study of 9 chronic stroke patients & reported that range of motion (ROM), speed, and accuracy of arm movement were more improved after mirror therapy [4].

Stevens and Stoykov also reported that their 2 stroke patients trained with mirror therapy for 3 to 4 weeks and had an increase in Fugl-Meyer Assessment score, active ROM, movement speed and hand dexterity after mirror therapy [6].

Sathian et al. found that 2 weeks of intense mirror therapy in a ehronic stroke patient resulted in a strong recovery of grip strength and hand movement in the paretic arm. In a recent randomized controlled trial [5].

Ramachandran suggested that mechanisms of pain relief are unclear, although mirror therapy resolves the visual-proprooceptive dissociation proposed as an explanation for PLP. The success of mirror therapy compared with both coverd mirror and mental visualization therapies indicated vision is the critical component in resolving pain and that the visual feedback provided by mirror therapy might allow vision to dampen any mismatch in brain signal perception [7].

Mirror therapy has also shown to be effective in relieving discomfort associated with non-specific pain disorders, such as Complex Regional Pain Syndrome (CRPS), or Reflex Sympathetic Dystrophy (RSD) [23].

Methodology

Sample

30 subjects are taken for the study and divided into two groups, group A and group B. The study was conducted in the Department of Physiotherapy, SGRRIMHS, patelnagar Dehradun(Uttrakhand). A sample of 15 subjects each in 2 groups were selected according to inclusion and exclusion criteria. Inclusion criteria includes Subacute stroke (4-6 wks), Absent or impaired cortical sensations, Impairment of hand functions, MAS 2-4, Male and female both & Age group 40-65 yrs. Exclusion criteria include Cognitive impairment, Global aphasia & Wernickes aphasia. Instrumentation-Intermittent pneumatic Compression machine, Mirror (35x35cms), Plinth, Stepper, Table & Pillow. (Fig. 1 & 2) Outcome measures Brunnstrom Motor Recovery Stages, Nottinghum Sensory Assessment & Functional Independence Measure.

Procedure

The subjects are invited to participate in the study. A detailed explanation of the procedure was given after which the subjects/caregiver signed the informed consent. Sample of convenience of thirty sub acute stoke subjects are selected and divided into group A and group B. Group A receive Intermittent Pneumatic Compression combine with Mirror Therapy for their hemiplegic upper limb. Intermittent Pneumatic Compression is given for 30 minutes a day, 6 days a week for 4 weeks and Mirror Therapy is given for two hours a day, 6 days a week for 4 weeks. Group B receive ROM exercises, stretching, strengthening exercises for 60 minutes/ day, 6 days a week for 4 weeks.

For Intermittent Pneumatic Compression, the treatment is given with the patient in supine lying and the angle between the trunk and arm is 45 degrees. Elbow, wrist and fingers are held in extension. A long arm inflatable pressure splint is applied on the affected upper limb. Then the splint is connected to an intermittent pneumatic compression machine. Inflation peak was set to 40 mmHg. The intermittent pressure procedure lasted 30 minutes. (Fig. 3).

During the mirror practices, patient is seated close to a table on which a mirror (35x35cm) was placed vertically. The involved hand is placed behind the mirror and the noninvolved hand in front of the mirror. The practice consist of nonparetic-side wrist and finger flexion and extension movements while patients looked into the mirror, watching the image of their noninvolved hand, thus seeing the reflection of the hand movement projected over the involved hand. Patients could see only the noninvolved hand in the mirror; otherwise, the noninvolved hand is hidden from sight. During the session patient is asked to try to do the same movements with the paretic hand while he is moving the nonparetic hand. (Fig. 4) The treatment for group B includes ROM exercises, stretching and strengthing exercises lasted for one houe.

Data Acquisition

Based on the performance of the individual the data was collected and recorded on data collection sheet. After completion of the study period the data was send for analysis.

Fig. 1: Intermittent Pneumatic Compression machine

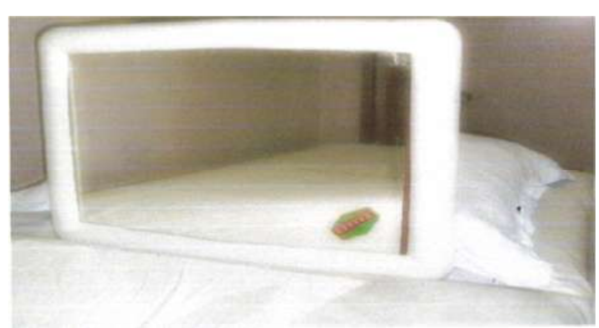

Fig. 2: Mirror

Fig. 3: Intermittent Pneumatic Compression treatment

Fig. 4: Mirror Therapy

Data Analysis

Statistics were performed by using Graph pad software. Results were calculated by using 0.05 level of significance. Unpaired t test was used to analyze and compare the score between groups A & B. A significance level of $p<0.05$ was set for data analysis.

Results

The chapter deals with the results of the data analysis of the three scales- Brunnstrom motor recovery scale, NSA and FIMS between group A and B. The scores were analyzed and interpreted to determine whethere hand functions improved by IPC and Mirror Therapy.

Unpaired t test was used to analyze and compare the score between groups A & B. A significance level of $p<0.05$ was set for data analysis.

Analyzing Brunnstrom Motor Recovery stages revealed significant changes in group A with mean and standard error mean (4.533±0.2153) when compared with group B with mean and standard error mean (3.267±0.1817). (Table 1 & Fig. 5)

Analyzing eating component of FIMs stages revealed significant changes in group A with mean and standard error mean (6.200±0.3117) when compared with group B with mean and standard error mean (5.200±0.6110). (Table 2 & Fig. 6)

Analyzing grooming component of FIMs stages revealed significant changes in group A with mean and standard error mean (5.333±0.2520) when compared with group B with mean and standard error mean (4.333±0.3333). (Table 3 & Fig.7)

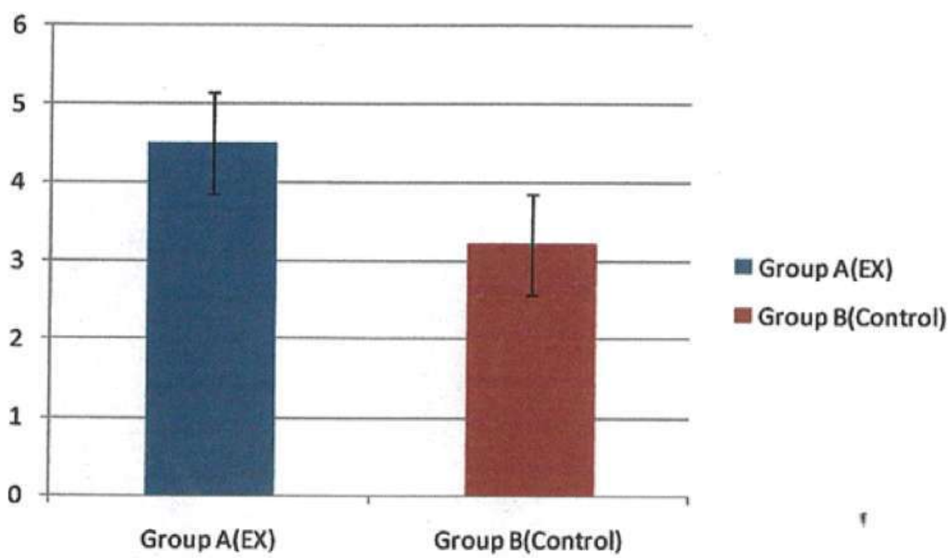

Fig. 5: Comparison of mean of Brunstrom Motor Recovery Stage

Table 1: mean, SEM, p value of Brunstrom Motor Recovery Stages

Group	Mean & SEM	P value
Group A	4.533±0.2153	< 0.05
Group B	3.267±0.1817	< 0.05

Analyzing bathing component of FIMs stages revealed significant changes in group A with mean and standard error mean (5.267±0.3838) when compared with group B with mean and standard error mean (4.333±0.3333). (Table 4 & Fig. 8)

Analyzing dressing upper body component of FIMs stages revealed significant changes in group A with mean and standard error mean (5.333±0.3608) when compared with group B with mean and standard error mean (5.067±0.3838). (Table 5 & Fig. 9)

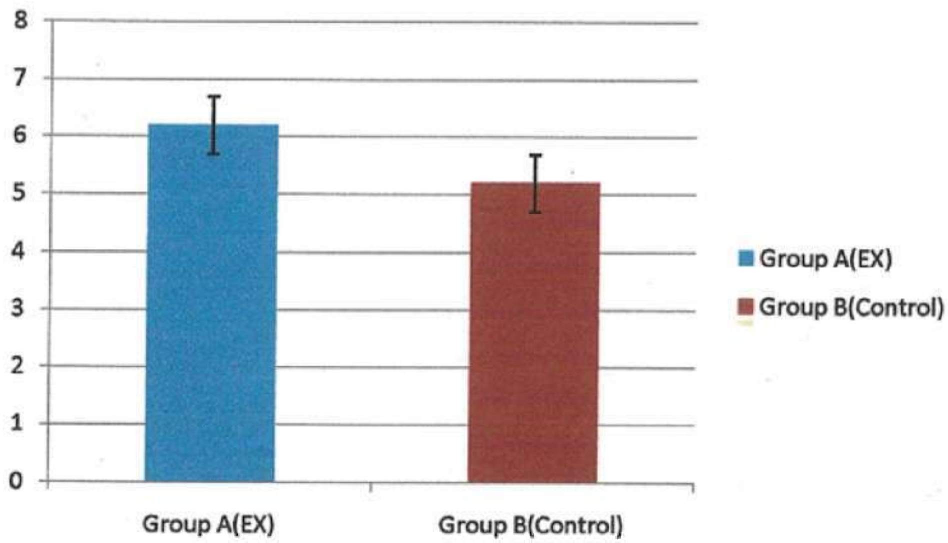

Fig. 6: Comparison of mean of eating component of FIMs

Table 2: mean, SEM, p value of eating component of FIMs

Group	Mean & SEM	P value
Group A	6.200 ± 0.3117	< 0.05
Group B	5.200± 0.6110	< 0.05

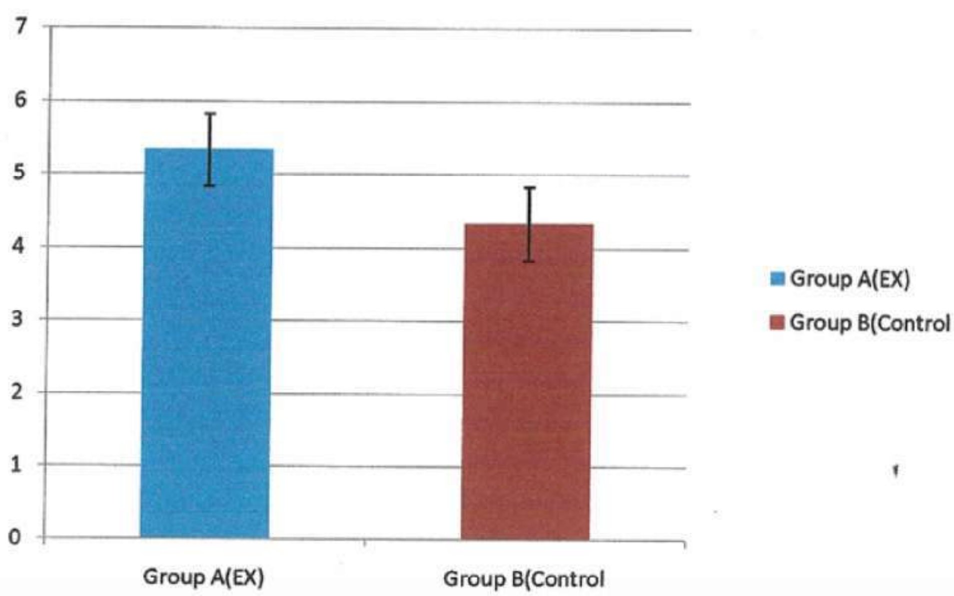

Fig. 7: Comparison of mean of grooming component of FIMs

Table 3: mean, SEM, p value of grooming component of FIMs

Group	Mean & SEM	P value
Group A	5.333± 0.2520	< 0.05
Group B	4.333±0.3333	< 0.05

Analyzing dressing lower body component of FIMs stages revealed significant changes in group A with mean and standard error mean (5.400±0.3491) when compared with group B with mean and standard error mean (4.867±0.4008). (Table 6 & Fig.10)

Analyzing pin prick component of NSA revealed significant changes in group A with mean and standard error mean (1.600±0.1309) when compared with group B with mean and standard error mean (0.9333±0.1817). (Table 7 & Fig. 11)

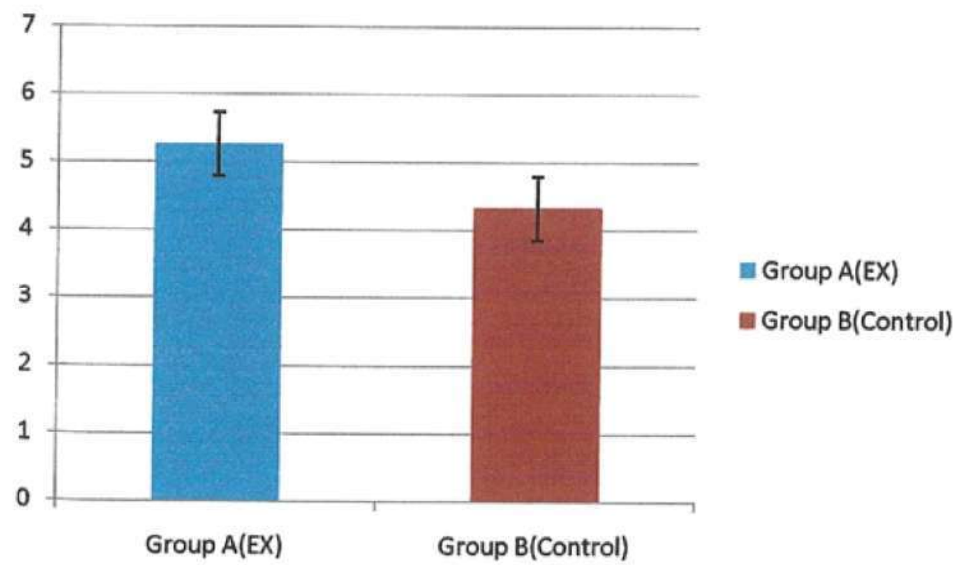

Fig. 8: Comparison of mean of bathing component of FIMs

Table 4: mean, SEM, p value of bathing component of FIMs

Group	Mean & SEM	P value
Group A	5.267± 0.3838	< 0.05
Group B	4.333± 0.3333	< 0.05

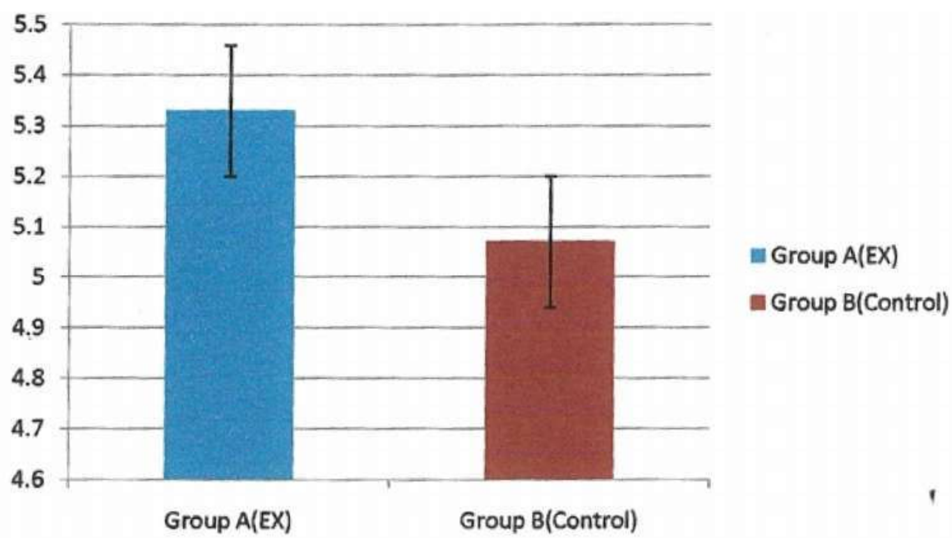

Fig. 9: Comparison of mean of dressing upper body component of FIMs

Table 5: mean, SEM, p value of dressing upper body component of FIMs

Group	Mean & SEM	P value
Group A	5.333±0.3608	< 0.05
Group B	5.067±0.3838	< 0.05

Analyzing light touch component of NSA revealed no significant changes in group A with mean and standard error mean (1.600 ±0.1309 when compared with group B with mean and standard error mean (1.600±0.1309). (Table 8 & Fig. 12).

Analyzing pressure component of NSA revealed significant changes in group A with mean and standard error mean (1.600±0.1309) as compared with group B with mean and standard error mean (1.400±0.1309). (Table 9 & Fig. 13).

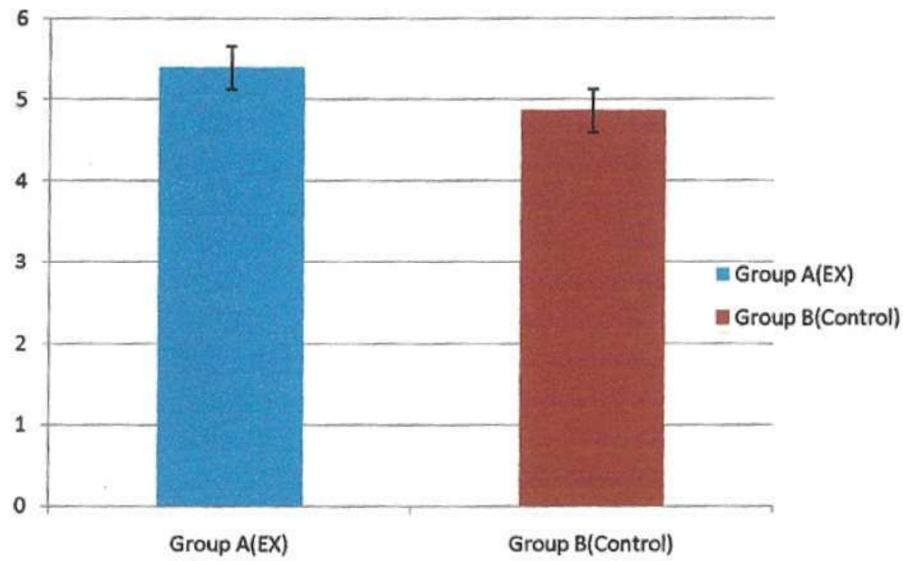

Fig. 10: Comparison of mean of dressing lower body component of FIMs

Table 6: mean, SEM, p value of dressing lower body component of FIMs

Group	Mean & SEM	P value
Group A	5.400± 0.3491	< 0.05
Group B	4.867±0.4008	< 0.05

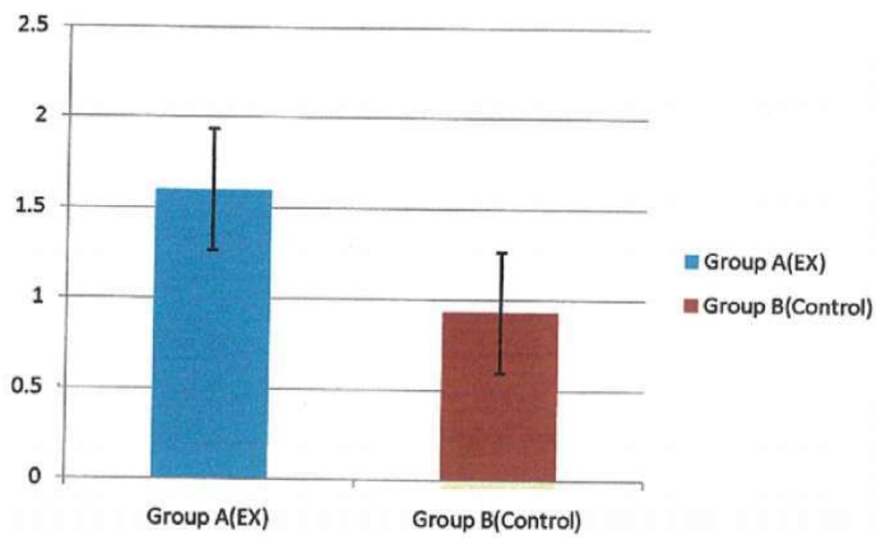

Fig. 11: Comparison of mean of pin prick component of NSA

Table 7: mean, SEM, p value of pin prick component of NSA

Group	Mean & SEM	P value
Group A	1.600±0.1309	< 0.05
Group B	0.9333 ±0.1817	< 0.05

Analyzing temperature component of NSA revealed significant changes in group A with mean and standard error mean (1.600±0.1309) as compared with group B with mean and standard error mean (1.333±0.1594). (Table 10 & Fig.14).

Analyzing proprioception component of NSA revealed significant changes in group A with mean and standard error mean (1.667±0.1594) as compared with group B with mean and standard error mean (1.071±0.1269). (Table 11 & Fig. 15).

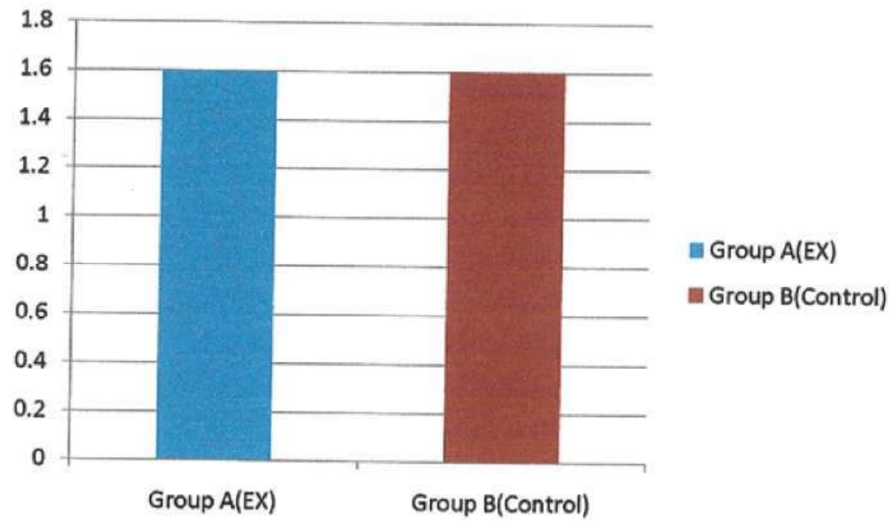

Fig. 12: Comparison of mean of light touch component of NSA

Table 8: mean, SEM, p value of light touch component of NSA

Group	Mean & SEM	P value
Group A	1.600±0.1309	< 0.05
Group B	1.600± 0.1309	< 0.05

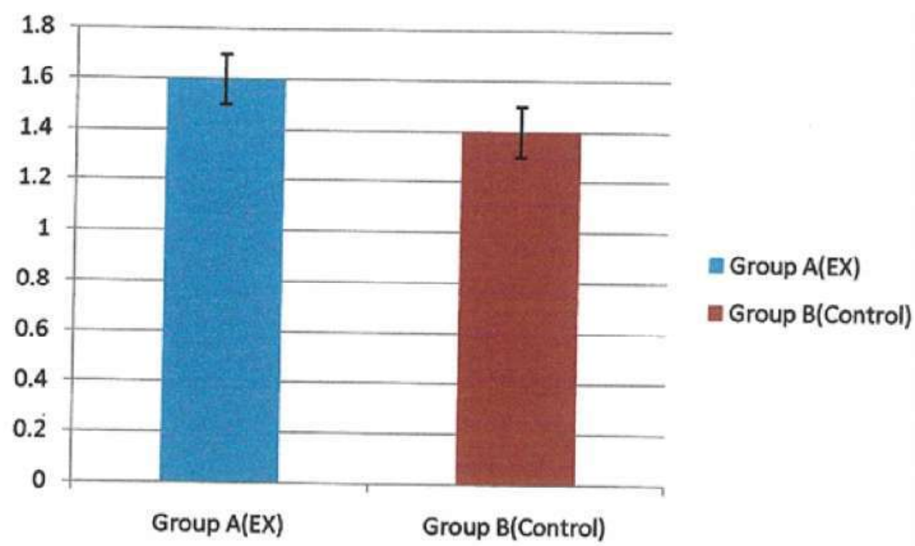

Fig. 13: Comparison of mean of pressure component of NSA

Table 9: mean, SEM, p value of pressure component of NSA

Group	Mean & SEM	P value
Group A	1.600±0.1309	< 0.05
Group B	1.400±0.1309	< 0.05

Analyzing stereognosis component of NSA revealed significant changes in group A with mean and standard error mean (1.733±0.1182) as compared with group B with mean and standard error mean (1.067±0.1182). (Table 12 & Fig. 16)

Analyzing double simultaneous stimulation component of NSA revealed significant changes in group A with mean and standard error mean (1.733±0.1182) as compared with group B with mean and standard error mean (1.067±0.06667). (Table 13 & Fig.17)

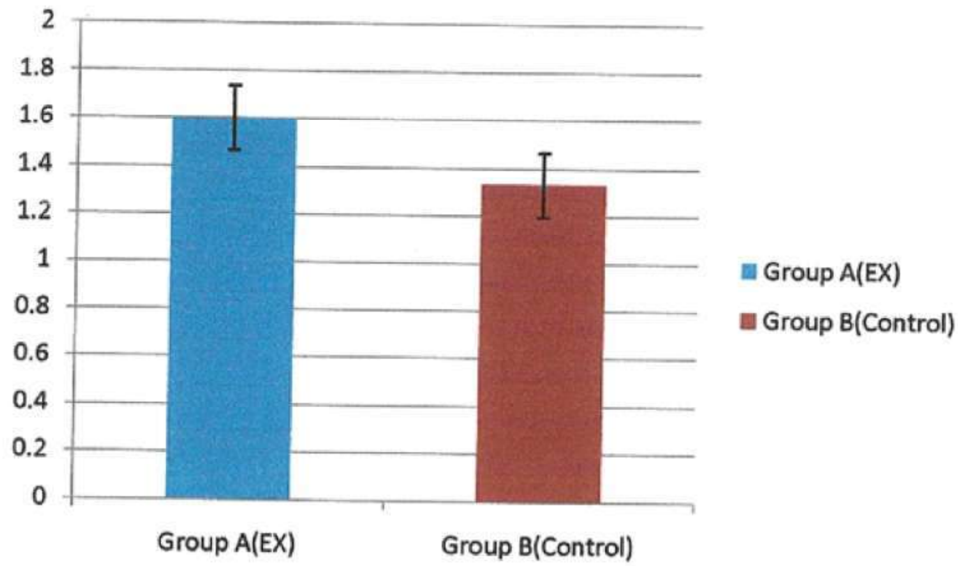

Fig. 14: Comparison of mean of temperature component of NSA

Table 10: mean, SEM, p value of temperature component of NSA

Group	Mean & SEM	P value
Group A	1.600±0.1309	< 0.05
Group B	1.333±0.1594	< 0.05

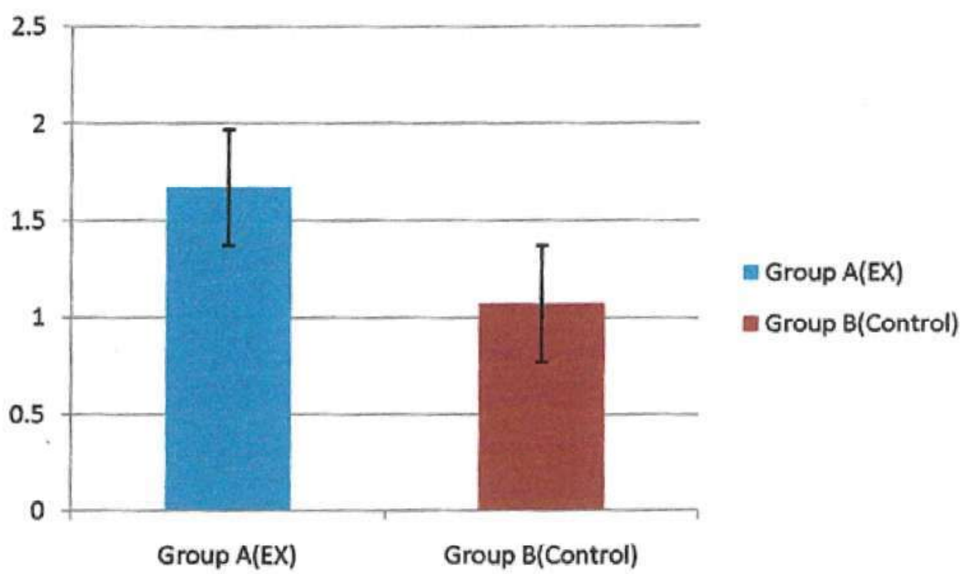

Fig. 15: Comparison of mean of proprioception component of NSA

Table 11: mean, SEM, p value of proprioception component of NSA

Group	Mean & SEM	P value
Group A	1.667±0.1594	< 0.05
Group B	1.071±0.1269	< 0.05

Discussion

Clinical Test for sensation (NSA), motor function (Brunstrom Motor Recovery Stages) and FIMS was used in this study to determine hand functions improved by Intermittent Pneumatic Compression and Mirror Therapy.

The results obtained revealed interesting findings in subacute stroke subjects. Sensory as well as motor function improved by Intermittent

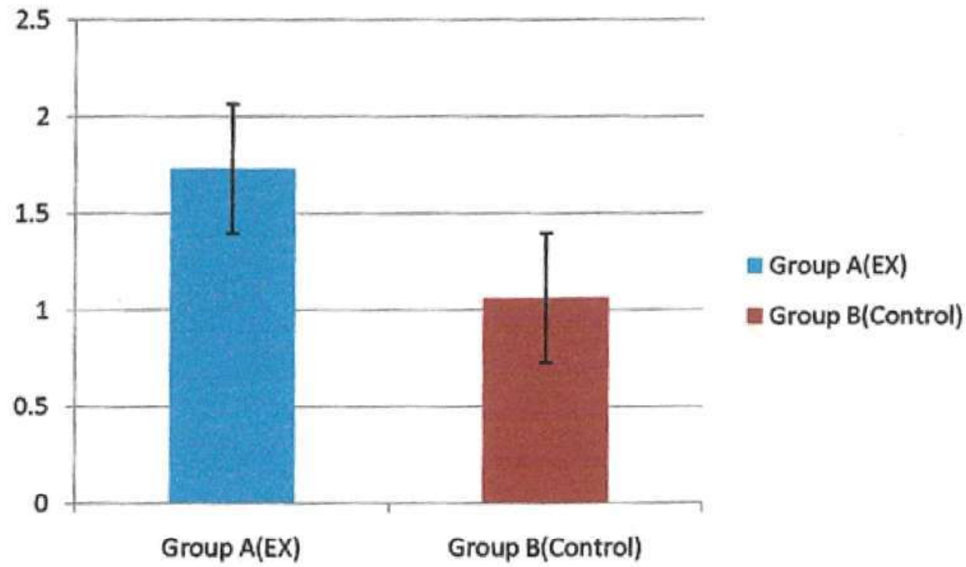

Fig. 16: Comparison of mean of stereognosis component of NSA

Table 12: mean, SEM, p value of stereognosis component of NSA

Group	Mean & SEM	P value
Group A	1.733± 0.1182	< 0.05
Group B	1.067±0.1182	< 0.05

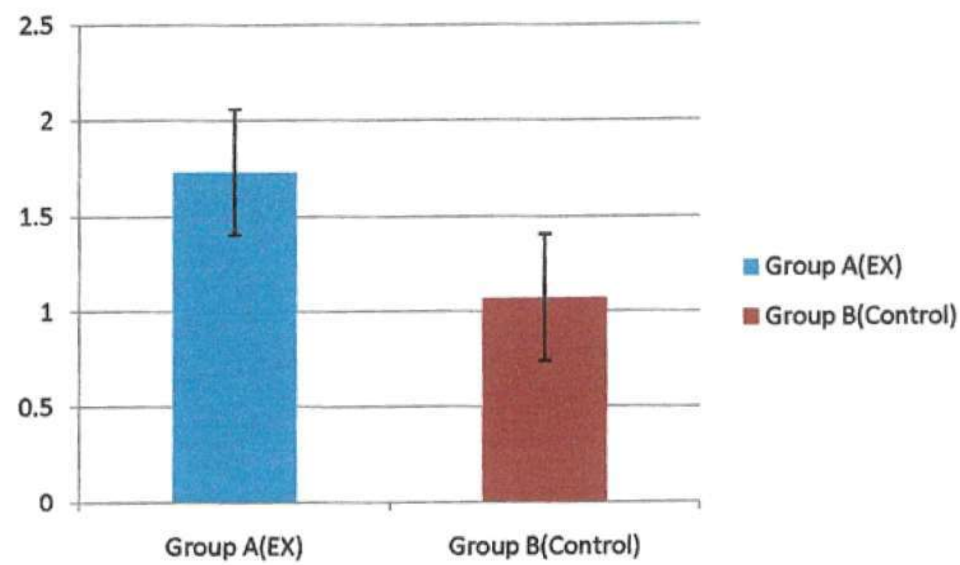

Fig. 17: Comparison of mean of double simultaneous stimulation component of NSA

Table 13: mean, SEM, p value of double simultaneous stimulation component of NSA

Group	Mean & SEM	P value
Group A	1.733±0.1182	< 0.05
Group B	1.067 ±0.06667	< 0.05

Pneumatic Compression and Mirror Therapy. Sensory impairment is improved by Intermitten Pneumatic Compression.

DC Cambier, E De Corte, et al. concluded that use of intermittent pneumatic compression in the rehabilitation of stroke patients may be of clinical importance for the restoration of sensory function [20].

Ganes Yavuner concluded that hand functions improved by Mirror Therapy in subacute stroke subjects [21].

Altschuler et al. reported that range of motion (ROM), spped, and accuracy of arm movement were more improved after mirror therapy [4].

Stevens and Stoykov also reported that their 2 stroke patients trained with mirror therapy for 3 to 4 weeks and had an increase in Fugl-Meyer Assessment score, active ROM, movement speed, and hand dexterity after mirror therapy [6].

Sathian et al. found that 2 weeks of intense mirror therapy in a chronic stroke patient resulted in a strong recovery of grip strength and hand movement in the paretic arm [5].

Altschuler et al. suggested that themirror illusion of a normal movement of the affected hand may substitute for decreased proprioceptive information, thereby helping to recruit the premotor cortex and assisting rehabilitation through an intimate connection between visual input and premotor areas [4].

Stevens and Stoykov suggested that mirror therapy related to motor imagery and that the mirror creates visual feedback of successful performance of the imagined action with the impaired limb [6].

Garry et al. performed transcranial magnetic stimulation during mirror illusions in healthy subjects and showed increased excitability of primary motor cortex (M1) of the hand behind the mirror [24].

Giraux and Sirigu found in increased activity in M1 corresponding with the affected limb using functiional magnetic resonance imaging [26].

Summers et al. investigated the effectiveness of bilateral arm training and reported that compared with unilateral training, bilateral training intervention was more effective in facilitating upper-limb motor function in chronic stork patients [27].

Study Limitations

1. Some factors that may have affected sensory assessment were not assessed, such as cognitive deficits, aphasia and mood; therefore the effect of these on sensory impairment and recovery could not be evaluated.
2. The sample was limited to those between the ages of forty to sixty-five years old.
3. This limitation should be recognized as it is known that somatosensory function decreases with age (Kenshalo, 1986, Kaplan et al, 1985, Desrosiers et al., 1996).
4. Time constraints meant that patients were only followed up for one month.

Future Research

1. The future research may investigate stroke patients with apraxia or neglect.
2. The research can be done on male and female subjects individually.
3. The research can be done for longer duration (eg. 6 months) and on a large sample size.

Conclusion

The study concluded that hand functions improved by Intermittent Pneumatic Compression and Mirror Therapy in sub-acute stroke subjects and interventions should be emphasize to restore motor and sensory function.

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