Research Article

iMedPub Journals
www.imedpub.com

Health Science Journal
ISSN 1791-809X

2022
Vol. 16 No. 3: 933

DOI: 10.36648/1791-809X.16.4.933

The Effect of Modified Constraint Induced Movement Therapy on Motor Performance and Daily Functions in Patients One To Nine Months after Stroke

Dr. Sobha Saseendrababu*

Assistant professor College of nursing Northern Border University Arar, Kingdom of Saudi Arabia

***Corresponding author:**
Dr. Sobha Saseendrababu

sobhasseendrababu@gmail.com

Assistant professor College of nursing Northern Border University Arar, Kingdom of Saudi Arabia

Citation: Saseendrababu S (2022) The Effect of Modified Constraint Induced Movement Therapy on Motor Performance and Daily Functions in Patients One To Nine Months after Stroke. Health Sci J. Vol. 16 No. 3: 933.

Abstract

Introduction: Stroke is the most common cause of disability in the adult and elderly population and one of the major causes of hospitalization. Impairment of upper limb function is among the most common motor disabilities and it has a great impact on functional and social independence of patients and thus these disabilities represent a major public health problem. Constraint Induced Movement Therapy is an intervention that has been used mainly for the treatment of the upper extremities for stroke patients. When a person's brain is damaged by a stroke, it often becomes more difficult to move an arm. Therefore, the person tends to use the arm less. This leads to shrinkage of the regions of the brain that control arm movement. Movement of the arm gets even more difficult. Constraint Induced Movement Therapy produces a large rewiring of the brain; that is after treatment, more of the brain works to move the weaker arm than before the therapy. The study was intended to identify the effect of Modified Constraint Induced Movement Therapy on motor performance and daily functions in patients one to nine months after stroke.

Major objectives of the study were,

1. To evaluate changes in motor performance of the upper extremity after Modified constraint Induced Movement therapy.

2. To evaluate changes in fine motor movements of the hand after Modified constraint Induced Movement therapy.

3. To identify changes in daily living functions in patients treated with Modified constraint Induced Movement therapy.

Materials and methods

The sample for the study were adult male and female persons one to nine months after stroke with hemiparesis or hemiplegia with age range from 40-80 years who attended the Neurology Department, Medical College, Thiruvananthapuram. After considering the inclusion and exclusion criteria the patients are grouped to two groups by using simple randomization technique. Total 210 patients were selected for the study with 105 in each experimental and control group. Both the groups were assessed by Fugl Meyer Assessment, Action Research Arm Test and the Barthel Index. The experimental group received standard therapy offered in the hospital along with the Modified Constraint Induced Movement Therapy. The control group received the standard therapy offered in the hospital. Follow up assessments were done in the 6th and 10th week by using the same assessment tools. Pre and post assessments were done by the neurologist.

In this study Modified Constraint Induced Movement Therapy means

1. Structured therapy emphasizing affected arm use in the functional task practice for 30 minutes /days for 3 days per weeks for 10 weeks

2. Less affected or unaffected arm restraint 5 days per weeks for 5 hours

Structured therapy includes functional practice sessions approached in small steps

of progressively increasing difficulty and multiple repetitions of functional task. It is divided into 5 sessions each with 2 weeks duration.

The patient is instructed to wear a constraint sling for 5 hours per day, 5 days a week for 10 weeks. The purpose of the sling was to act as a reminder to refrain from using his less affected or non-affected hand for functional activities. However, the sling allows them to use that arm for gross movement and support for a loss of balance if needed.

The findings of the study showed that the group treated with Modified constraint Induced Movement Therapy had highly significant improvement in the motor performance of the upper extremity as measured by the Fugl Meyer Assessment (p=0.000), fine motor movements of the hand, especially grasp, grip, pinch and gross movement function indicated by the Action Research arm Test score (p=0.000) and improved ability in meeting the activities of daily living as measured by the Barthel Index score (p=0.000).

Conclusion: This study proved that Modified constraint Induced Movement Therapy is more effective in improving the motor performance of the upper extremity, fine motor movements of the hand and thereby increasing the ability to meet activities of daily living in stroke patients.

Keywords: Canned drinks; microorganism; health implications

Received: 10-Feb-2022, Manuscript No. iphsj-22-12506; **Editor assigned:** 12-Feb-2022, PreQC No. iphsj-22-12506 (PQ); **Reviewed:** 25-Mar-2022, QC No. iphsj-22-12506, **Revised:** 31-Mar-2022, Manuscript No. iphsj-22-12506(R); **Published:** 08-Apr-2022, DOI: 10.36648/1791-809X.16.3.933

Introduction

“Nobody can go back and start a new beginning,

But anyone can start today and make a new ending”

(Maria Robinson)

Stroke remains as one of the most devastating of all neurological diseases, often causing death or gross physical impairment or disability. As many countries throughout the world undergo the epidemiological transition of diseases, trends in the prevalence of stroke have dramatically changed. The global burden of stroke is high, inclusive of increasing incidence, mortality, DALYs, and economic impact, particularly in low and middle income countries. The implementation of better surveillance systems and prevention programs are needed to help track current trends as well as to curb the projected exponential increase in stroke worldwide (Mukherjee D and Patil CG, 2011).Currently there are more than 6.5 million people living who have had strokes. Of these who survive, 50% to 70% will be functionally independent and 15% to 30% will live with permanent disability. Twenty percent will require long term care after 3 months. Common long term disabilities include hemi paresis, inability to walk, complete or partial dependence in activities of daily living, aphasia and depression. In addition to the physical, cognitive and emotional impact of the stroke on the survivor, the stroke affects the life of the caregiver, and family of the stroke victim (Lewis et.al, 2011). An increasing body of scientific evidence suggests that cortical functional reorganization occurs after central nervous system damage, and that this reorganization interacts with environmental influences that may facilitate functional recovery. In stroke patients, upper limb paresis affects many activities of daily life. Reducing disability is therefore a major aim of rehabilitation programmes for hemiparesis patients. Constraint-induced movement therapy (CIMT) is a current approach to stroke rehabilitation that implies the forced use and the massed practice of the affected arm by restraining the unaffected arm. Modified CIMT, as developed by Page and colleagues, represents a distributed practice pattern in which the mitt is worn for several hours each day over a 10-week period and this home-based practice is supplemented with outpatient therapy several times each week. It is interesting that 27 years after the original formulation of CIMT, the ability of a patient to initiate finger extension has been validated as a primary predictor of the successful application of CIMT **[1].**

Background of the Study

Stroke is a major public health concern. It is the second leading cause of mortality worldwide and third most common cause of death in the industrialized world. Currently there are more than 6.5 million people living who have had strokes. Of these who survive, 50% to 70% will be functionally independent and 15% to 30% will live with permanent disability. Twenty percent will require long term care after 3 months. Common long term disabilities include hemi paresis, inability to walk, complete or partial dependence in activities of daily living, aphasia and depression. In addition to the physical, cognitive and emotional impact of the stroke on the survivor, the stroke affects the lives of the caregiver, and family of the stroke victim (Lewis et. al, 2011). More than 80% of the stroke survivors have paresis of the UL, and 30%-60% of these patients cannot use the paretic UL (PUL) which compromises their independence and quality of life **[2].**

Decreased arm function is common following stroke and impacts on a person's ability to perform activities of daily living **[3].**

Constraint induced movement therapy was developed at the University of Alabama Birmingham By Edward Taub as Director for the CI therapy research group. The study by Taub showed brain activity actually improves with CIMT treatment. "This finding offers hope to researchers who believe it may be possible to stimulate or manipulate brain areas to take over lost functions, a process known as cortical reorganization," says Dr. Taub.

Constraint induced therapy is intended to help stroke patients overcome 'learned nonuse' of the paretic arm by discouraging the use of the unaffected or less affected arm in combination with intensive training of the paretic arm.

CIMT consists of three components

- Massing of repetitive, structured, practice-intensive therapy in use of the more-affected arm
- Restraint of the less-affected arm
- Transfer program, which includes monitoring arm use in life situations and problem solving to overcome perceived barriers to using the extremity **[3].**

The initial protocol for constraint Induced movement therapy offers

- Promoting use of the more affected upper extremity for a target of 90% of waking hours by restraining the less affected upper extremity for 2-3 weeks'.
- Training of the more affected upper extremity is given 6 hours daily for 10 consecutive week days during that period (massing of practice or concentrated, repetitive training).

A prospective single blinded, randomized controlled study to investigate the beneficial effect of Modified Constraint Induced Movement Therapy in improving the function of hemiplegics upper extremity in the early sub-acute stroke patients concluded that significant improvement in hand function could be achieved with the therapy in sub-acute patients, which was maintained up to 12 weeks follow up **[4].**

In addition to improving functional use of the affected arm and daily functioning Modified Constraint Induced Movement Therapy improved motor control strategy during goal directed teaching, a possible mechanism for the improved motor performance of stroke patients undergoing this therapy. Now the trials are underway to determine the cost-effective ways to offer the therapy and totally home based computer assisted constraint induced movement therapy.

Statement of the Problem

A study to assess the Effect of Modified Constraint Induced Movement Therapy on motor performance and daily functions in patients one to nine months after stroke.

Operational Definitions

Effect

In this study, the word effect implies the outcome of Modified Constraint Induced Movement Therapy on motor performance and daily functions in patients 1-9 months after stroke as evidenced by increased scores in Fugl Meyer assessment, Action Research Arm Test and Barthel Index.

Modified Constraint Induced Movement Therapy

Modified Constraint Induced Movement Therapy encourages the patient to use the weakened extremity by restricting the movement of the normal extremity. In this study Modified constraint Induced Movement Therapy consisting of:

1. Structured therapy emphasizing affected arm use in functional activities for 30 minutes per days for 3 days per weeks for 10 weeks.
2. Less affected arm or non-affected arm restraint 5days / weeks for 5 hours.

Motor Performance

In this study the motor performance means the scores obtained by assessing the hand function using Fugl Meyer Assessment and Action Research Arm Test.

Daily Functions

In this study Daily function means the person's ability to meet the self care needs such as feeding, bathing, grooming, dressing, elimination needs and mobility as per the scores obtained by using The Barthel Index.

Stroke

Stroke is defined as rapidly developed clinical signs of focal (or global) disturbance of cerebral functions lasting more than 24 hours or leading to death, with no apparent cause other than a vascular origin. Included are subarachnoid hemorrhage, intracerebral haemorrhage and ischemic brain infarction, both embolic and non embolic. Transient ischemic attacks are excluded according to this definition

Patients

Adult male and female persons 1-9 months after stroke with hemiparesis or hemiplegia with age range from 40-80 years.

Objectives

General Objectives

To evaluate changes in motor performance of the upper extremity and daily functions in patients treated with Modified constraint Induced Movement Therapy as evidenced by increased post test scores in Fugl Meyer Assessment, Action Research Arm test and The Barthel Index.

Specific Objectives

1. To evaluate changes in motor performance of the upper extremity after Modified Constraint Induced Movement Therapy as measured by pretest and posttest Fugl Meyer Assessment scores.

2. To evaluate changes in fine motor movements of the hands evidenced by increased scores in Action research Arm Test after Modified Constraint Induced Movement Therapy

3. To evaluate changes in daily functions in patients treated with Modified Constraint Induced Movement Therapy as evidenced by increased scores in the Barthel Index.

Hypothesis

Null Hypothesis

Modified Constraint Induced Movement Therapy will not influence motor performance and daily functions in patients 1-9 months after stroke.

Alternate hypothesis

Modified Constraint Induced Movement Therapy will influence motor performance and daily functions in patients 1-9 months after stroke.

Methodology

Research Approach

In the present study experimental approach was used to identify the effect of Modified Constraint Induced Movement Therapy on motor performance and daily functions in stroke patients.

Research Design

The present study is a randomized controlled trial to assess the effect of modified constraint induced movement therapy on motor performance and daily functions in stroke patients. The researchers study the cause and effect relationship between Modified Constraint Induced Movement Therapy and motor performance and daily functions are studied and compared with the standard therapy used in the hospital. In this study the independent variable is an example of treatment variable, that is Modified Constraint Induced Movement Therapy and the dependent variables are motor performance and daily functions as evidenced by scores in Fugl Meyer Assessment, action Research Arm Test and The Barthel Index.

In the present study the investigator tried to reduce or eliminate all factors that influence the dependent variable other than the independent variable. This is done by Research manipulation, use of a control group and randomization. Here the modified Constraint Induced Movement Therapy is administered to the experimental group along with the standard therapy offered in the hospital and the control group received only the standard therapy offered in the hospital. The pre and post scores were compared in both groups to identify the effect of therapy. The use of a control group helps the researcher to generalize the results in comparison with the control group. The use of randomization ensures that each subject has an equal chance of being place in to experimental or control group. The selection bias is avoided by randomization of samples to experimental group and control group. The investigator also tried to control the research situation by maintaining the constancy of condition and constancy of communication. The investigator prepared the information giving to the participants ahead of time and delivered the same message to all participants. Also care is taken in the preparation and adherence to the intervention protocol. The cause and effect relationship thus measured will truly reflect the effect of modified Constraint Induced Movement Therapy.

Setting of the Study

The setting of the study was the Out Patient Department, Department of Neurology, Tertiary Care centre, Medical college Hospital, Thiruvananthapuram. The Out Patient Department Days are on Monday, Thursday and Saturday from 9 am to 5 pm.

Population

The patients having stroke who come to the Department of Neurology, Medical College, Thiruvananthapuram, during the study period and in the age group of 40-80 years.

Sample Size

Adult male and female persons 1-9 months after stroke with hemiparesis or hemiplegia age range from 40-80 years were selected for the study.

After conducting the pilot study the sample size is calculated by using the following formula

$$n = \frac{P_1(100-P_1)+P_2(100-P_2)}{(P_1-P_2)^2} \times (2\propto + Z\beta)^2$$

$$= \frac{20\times 80 + 40\times 60}{400} \times 10$$

$$= \frac{1600+2400}{400} \times 10$$

$$= 100$$

$$2n = 2\times 100$$

$$= 200$$

$P_1 = 20$

$P_2 = 40$

$Z^{\propto} = 1.96$

$Z^{\beta} = 1.28$

By using the above formula the total patients required for the study was calculated as 200. 5% extra was added to the total population and the sample size for the study finalized as 210, 105 each in the experimental and control group.

Sample Size is finalized as,

No. of patients in the Experimental group = 105

No. of patients in the control group = 105

Sampling Technique

The patients having stroke comes to the department of Neurology, Medical College, and Thiruvananthapuram during the study period and in the age group of 40-80 years were the target population for the study. Eligible samples were selected after considering the inclusion and exclusion criteria based on the baseline and clinical assessment made by the researcher guided by the Neurologist. After that, the eligible samples were randomized in to two groups, experimental group and control group by using simple randomization technique. Computer generated random

digit table was used to facilitate the randomization process.

Duration of the Study

The duration of the study was 3 years 6 months from January 2010 to July 2013.

Inclusion Criteria

1. Adult male and female persons 1-9 months after stroke with hemiparesis or hemiplegia
2. Patients with first ischemic stroke
3. The persons selected within the age group of 40-80 years
4. Patients with the ability to extend the Meta carp phalangeal and inter phalangeal joints at least 10 degree and actively extend the wrist at least 20 degree.
5. Patients with spouse, son or daughter who is willing to give support and directions in the home as per the advice of the investigator.
6. The patients who give a signed consent form to participate in the study.

Exclusion Criteria

1. Comorbidities which may affect the outcome of management such as Renal failure, Cardiac contraindications and Neuropathies.
2. Cognitive problems, mentally ill, confused or disoriented and aphasia
3. Non cooperative patients
4. Patients who are receiving interventions like Sidha , Homeo and Ayurveda

Tool and Technique

Tool

The tools used in the study were the following

1. Structured Interview Schedule
2. Fugl Meyer Assessment
3. Action Research Arm Test
4. The Barthel Index

Technique

The techniques used for collecting the data were the following

1. Interview
2. observation
3. Measuring fugl Meyer assessment score
4. Assessment of scores in Action Research Arm Test
5. Assessment of scores in the Barthel index
6. Teaching
7. Demonstrations

Tool-1: Structured Interview Schedule

The structured interview schedule consisted of two sections

Section. A: Baseline Data of the participant

The baseline data of the client include age, sex, religion, education, marital status, dietary habits and personal habits

Section B: Clinical Data of the participant

In this study Clinical Data of the client consisted of co morbid condition of the client, clinical features, Diagnosis, and routine blood investigation findings.

Tool -11: Fugl Meyer Assessment of Physical Performance

In the present study, The Fugl Meyer Assessment developed by Fugl-Meyer et al., (1980) is used to measure the motor performance of the upper extremity in stroke patients. It is a performance based measure that provides quantitative assessment of voluntary movement, balance, sensation, passive range of motion, and pain. The FM is based on the patterns of motor recovery delineated by Twitchel (1951). Items in the motor section were developed from the seven stages of motor recovery following stroke described by Brunnstorm (1970), and items in the passive range of motion section were derived based on the standards of the American Academy of Orthopaedic surgeons. Test items are rated according to a 3- point ordinal scale from 0 (no function) to 2 (full function), secondary to direct observation of patient functioning. Scores across the five sessions are summed for a maximum total score of 226 **[5].**

The measure has been found to possess adequate inter –rater and test –retest reliabilities **[6].** The total motor score is the most commonly used subscale of the Fugl Meyer Assessment, and various investigators have proposed numerical ranges for categorization of stroke severity **[5-7].** In this study, the upper extremity sub scale of Fugl Meyer Assessment developed by Fugl Meyer (1980) is used to measure the motor performance of the upper extremity in stroke patients.

In this study the assessment included testing of 9 areas such as

- Reflexes (Maximum possible score-4)
- Flexor Synergy (Maximum possible score-12)
- Extensor Synergy (Maximum possible score-6)
- Movement combining Synergies (Maximum possible score-6)
- Movement out of Synergy (Maximum possible score-6)
- Normal Reflex Activity (Maximum possible score-2)
- Wrist-Stability, flexion, extension and circumduction (Maximum possible score-10)
- Hand- finger mass flexion, extension, and grasp (Maximum possible score-14)
- Coordination, tremor, dysmetria and speed (Maximum possible score-6)

Total maximum score of upper extremity = 66

Tool- 111: Action Research Arm Test

The Action Research Arm Test is scored on a four level ordinal scale (0-3) **[8],** there are four subtests: Grasp, Grip, Pinch, and Gross Movement. Items in each are ordered so that:

- If the subject passes the first, no more need to be administered and he scores top marks for that sub test;
- If the subject fails the first and fails the second, he scores zero, and again no more tests need to be performed in that subject;
- Otherwise he needs to complete all tasks within the subtest
- The Action Research Arm Test was scored in the following way
- 0 = cannot perform any part of the test
- 1 = perform the test partially
- 2 = complete the test, but takes an abnormally long time, varying from 50- 60 seconds.
- 3 = perform the test normally in less than 5 seconds.

Grasp sub scale consisted of 6 items and the total score ranged between 0-18

Grip sub scale consisted of 4 items and the total score ranged between 0 -12

Pinch sub scale consisted of 6 items and the score ranged between 0-18

Tool-1V: Barthel Index: The Barthel Index developed by Mahoney& Barthel in 1965 is used in the present study to assess the daily functions of the patient. It is a 10 item measure developed to assess functional independence in personal care and mobility in persons with neuro muscular and musculoskeletal disorders. Items emphasize various activities of daily living, including feeding, transferring, personal hygiene, toileting, bathing, mobility, dressing and controlling bowel and bladder functions. Each item is assigned a score of 0, 5, 10, or 15, with differential weighting reflecting the relative importance of each disability with respect to level of assistance required for performance. Items are summed to obtain a total score ranking from 0-100, with a score of 100 representing the highest degree of independence. Excellent internal consistency and reliability has been demonstrated in persons with stroke undergoing rehabilitation, with Cronbach's coefficient alphas of 0.87 at time of admission and 0.92 at time of discharge (Shah et. al, 1989). Adequate inter- rater and test-retest reliabilities also have been shown, with kappa scores of 0.70-0.88 (Loewen and Anderson, 1988) and 0.98 (Wolfe et. al, 1991), respectively.

The Barthel Index has been extensively studied and has had high construct validation **[9].** It has also been shown to have high inter rater reliability **[10].**

The scores can be obtained from discussing the questions with the patient and family.

Pilot Study

After obtaining permission from the Head of the Department, Neurology and ethical clearance from the Medical College, Thiruvananthapuram Pilot study was conducted to determine the feasibility, reliability, validity and practicability of the designed tool and research methodology. Pilot study was conducted from 01/02/2010-30/06/2010 in the Out Patient Department, Department of Neurology, Medical College, and Thiruvananthapuram.

After satisfying the inclusion and exclusion criteria experimental group and control group were selected by simple randomization. Pilot study was conducted in 20 participants after obtaining individualized consent in local language from the participant and one relative. Modified Constraint induced movement therapy was administered along with the standard therapy to the experimental group. The control group received the standard therapy offered in the hospital. The Protest and post test scores of experimental and control groups obtained at the 1st week, 6th week and 10th week were compared and analyzed using appropriate statistical methods and discussed with the experts.

In order to assess the effectiveness of Modified Constraint Induced Movement Therapy on motor performance and daily functions one way repeated measures ANOVA was carried out. The F value (3802.53) on Fugl meyer assessment, F value (1201) on The Barthel Index and F value (1923.01) on Action Research Arm Test shows that the variation in the scores are significant at 0.01 level.

After analysing the pilot study, results were discussed with the experts. The pilot study helped in testing the feasibility and practicability of the tool.

Data Collection Process

The investigator obtained prior permission for the conduct of the study from the Head of the Department, Department of Neurology, Medical College, and Thiruvananthapuram. Ethical committee clearance was obtained from The Human Ethical Committee, Medical College, and Thiruvananthapuram

Total 210 samples were selected after satisfying inclusion and exclusion criteria and randomized by simple randomization method using computer generated random digit table. The investigator met each participant individually; established rapport with them and the purpose of the study was explained to them. It was assured to them that all data will be kept confidential and used only for the study purpose. After that verbal and written consent of the participants in English/ local language were obtained for the study.

Initial assessment of all participants was done by the researcher which included collecting the baseline data and clinical data and Fugl Meyer Assessment, Action Research Arm Test and Barthel Index. Based on the randomization interventions were provided.

Experimental Group

After the initial assessment the investigator herself taught about modified constraint induced movement therapy to the patient and responsible bystander. On the first day of each session, the researcher demonstrated how to practice that particular session of the therapy and 30 minutes practice session was done

under the supervision of the researcher. Return demonstration by the patient and bystander also done to make sure that the participant can do the home therapy sessions in the proper way. It was instructed to maintain an activity diary for the participant and bystander about the sessions in the home. The researcher herself makes sure that the participant is doing the sessions by observing the diary and through phone call.

In this study modified constraint induced movement therapy means

1. Structured therapy emphasizing affected arm use in functional task practice for 30 minutes/ days for 3 days per weeks for 10 weeks

2. Less affected or unaffected arm restraint 5 days per weeks for 5 hours **(Figure 1).**

Structured therapy includes functional practice sessions approached in small steps of progressively increasing difficulty and multiple repetitions of functional task. It is divided in to 5 sessions each with two weeks duration.

The structured therapy consists of 5 sessions in small steps of progressively increasing difficulty .The investigator herself teach and assist the patient to practice the structured therapy at 1st , 3rd, 5th , 7th , and 9th week. The taught practice has to be repeated by the patient in the home therapy sessions under the supervision of caregiver.

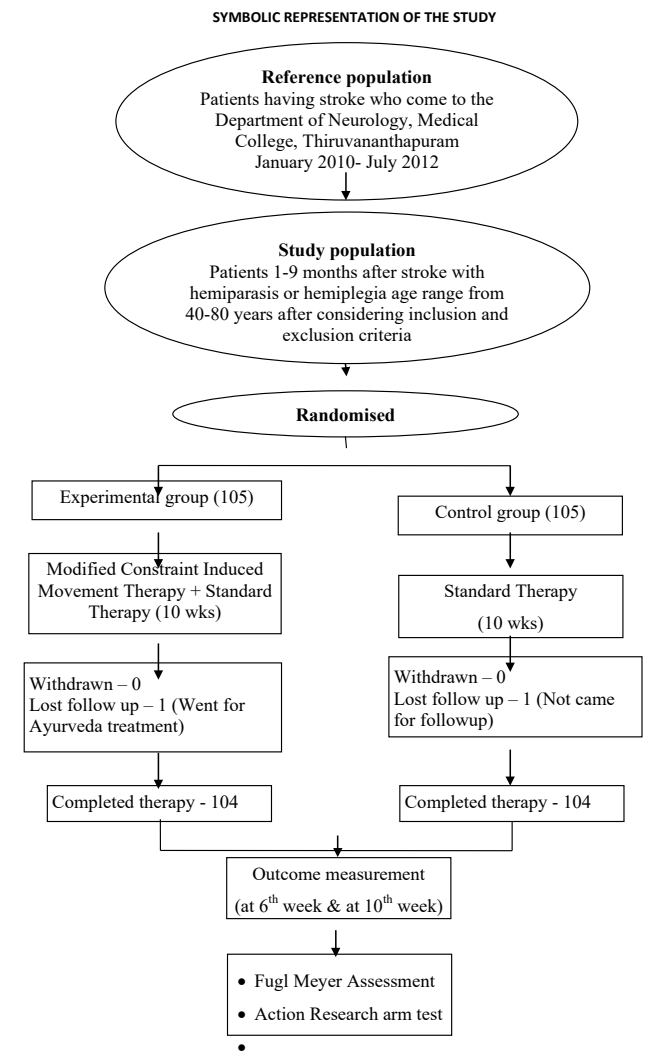

Figure 1 Symbolic Representation of The Study.

The patient is instructed to wear a constraint sling for 5 hours per day, 5 days a week for 10 weeks. The purpose of the mitt is to act as reminder to refrain from using his less affected or non-affected hand for functional activities. However the mitt allows them to use that arm for gross movements and support for a loss of balance if needed.

Structured therapy is divided in to 5 sessions each with two weeks duration.

1st and 2nd weeks

Sitting with arm on the table. Brief stretch with hand on the table top. Lifting and lowering an object (glass) held in palm and fingers over end of table. Lifting glass from table by radial deviation at wrist, fore arm in mid rotation, placing it to left and right by wrist flexion and extension. Sliding glass along table top to target by extending wrist.

Tapping tasks

1. Touch each fingertip to thumb in sequence as rapidly as possible.

2. Tapping table with single fingers.

3rd and 4th Weeks

1. Reach out and pass the glass by sliding arm on the table . Slide glass forward in different directions (across the body, out to the side) to touch targets keeping fore arm in mid rotation.

2. Hand cupping tasks to train opposition of radial and ulnar sides of the hand

a, Hold seeds in palm and pour in to a dish

b, scooping coins from table top in to palm of other hand

5th and 6th week

1. Slide glass backwards and fore wards to touch targets by extending and flexing elbow

2. Pick up different objects between thumb and finger , place them on various targets

a. Pick up objects between thumb and 4th and 5th fingers.

b. Pick up small objects from inside a cup with thumb and several fingers, thumb and fore finger

c. Pick up paper from opposite shoulder

d. Pick up and hold saucer using grip in which hand spans the whole diameter, thumb extended to the maximum, fingers stretched wide.

7th and 8th Weeks

1. Reach forwards, sideways or backwards to pick up an object, transport it to another place (eg. To the floor) pick it up

again reach as far in one direction as possible then put it down

2. Pick up larger objects from one side of table and place to other side; vary weight, distance to be moved

a, Pick up a glass of water and drink

b, Pick up jug of water and pour in to glass; vary amount of water and size of jug

9th and 10th Weeks

1. a, Point to different parts of a target drawing on sheet of paper on wall

b, Reaching up to take object from shelf, vary height according to ability

2. a, turn door handles or knobs

b, turn pages of magazine.

At 12th week the reassessment of the patient was done to assess the effect of modified constraint induced movement therapy. The outcome was measured by using Fugl Meyer Assessment, Action Research Arm Test and barthel Index.

Control Group

After the initial collection of the baseline data, pre assessment was done by using Fugl Meyer Assessment, action Research Arm Test and barthel Index. The researcher herself makes sure that the participant is getting the standard therapy offered in the medical college hospital. The initial step in the therapy includes the following.

1. Keep the affected upper extremity in abducted position at the shoulder, most of the time especially during sleep. This is to prevent periarthritis shoulder).

2. While in bed keep the affected arm abducted at 90^0. Flex the elbow to 90^0 passively, and then externally rotate till the fore arm touches the bed. Then internally rotate 180^0 again so that fore arm touches bed. Again externally rotate 180^0 so that the fore arm touches bed. Repeat this passive exercise to prevent periarthritis shoulder.

3. Hold the upper extremity at the wrist and then passively rotate at the shoulder. This is to prevent periarthritis shoulder.

4. In sitting position place hand on bed with elbow in extension and fingers spread out. Tap over the triceps muscle. This is aimed to increase extensor tone in the upper extremity and prevent flexor synergy.

5. Patient lie in supine position. Flex at the knee joint 90^0 with foot placed on the bed. Patient is encouraged to lift the buttocks up and down actively. This will help to strengthen the paraspinal muscles.

6. The therapist stands on the side of paralyzed side of the patient. Patient lies towards the edge of the bed on that side. The therapist holds the thigh just above the knee joint and with the other hand holds the foot just above the ankle joint, and flex at the hip 90^0 and flex knee to 90^0. Internally rotate at the hip joint as far as possible. Extend at the hip joint 5 to 10 degree with knee beyond the edge of the bed, maintaining the 90^0 flexion at the knee. Then extend the knee joint. The leg which is beyond the edge of the bed is returned to the bed. This is aimed to reduce adductor spasticity.

7. Patient lie in supine position. Flex at the knee joint 90^0 with foot placed on the bed. Separate the knee joint as far as possible. This involves external rotation and abduction of the hip joint. Then return to the apposed position. This is also aimed to reduce adductor spasticity.

8. At the end of the 12th week the outcome was measured by using Fugl Meyer Assessment, Action Research Arm Test and Barthel Index.

Plans for Data Analysis

The collected data were transformed in to the master sheet and necessary coding was done and the following statistical tests were done. Diagrams and charts were also drawn wherever necessary to give due importance to most salient findings. For all computations SPSS package was used.

Three kinds of average or statistical measures of central tendency were used- the mode, median and mean.

$$SD = \sqrt{\frac{\sum (x-\bar{x})^2}{n-1}}$$

Chi square test

Comparison of demographic data of the participants in experimental and control group was done by using Chi square test.

The chi square test is a non-parametric procedure used to test hypothesis about proportions of cases that fall in to different categories, as when a contingency table has been created. The Chi square statistics is computed by comparing observed frequencies and expected frequencies. Expected frequencies were calculated on the basis of observed total frequencies for the rows and columns of a contingency table **[11].**

Need to insert the formula of chi-square test

O=observed frequency

E= Expected frequency

Independent "t" test

The parametric procedure used for testing differences in group means is called the "t" test.

In this study Independent "t" test was used for testing the statistical significance of differences between two group means.

$$t = \frac{\bar{X}_A - \bar{X}_B}{\sqrt{\frac{\sum X_A^2 + \sum X_B^2}{n_A + n_B - 2}\left(\frac{1}{n_A} + \frac{1}{n_B}\right)}}$$

One Way Repeated measures ANOVA

In order to assess the effectiveness of Modified Constraint Induced Movement Therapy and standard treatment on

motor performance and daily functions One way Repeated Measures ANOVA was carried out. In experimental and control group Fugl Meyer Assessment, Action Research Arm Test and Barthel index scores were assessed at different stages such as pre intervention(1st week), 6th week and 10th week of post intervention. One way repeated measures ANOVA test was used to find whether the variation at different stages is significant or not.

Analysis of covariance (ANCOVA)

ANCOVA tests the significance of differences between group means after first adjusting the scores on the dependent variable to remove the effect of covariate, so that the results more precisely reflect the effect of an intervention. The adjustment uses regression procedures. In essence the first step in ANCOVA is the same as the first step in hierarchical multiple regression. Variability in the dependent measure that can be explained by the covariate is removed from further consideration. ANOVA is performed on what remains of Y's variability to see whether, once the covariate is controlled, significant differences between groups means exist.

Computation of ANOVA for repeated measures is given below. First obtain the values N and n.

Analysis of covariance (ANCOVA)

ANCOVA tests the significance of differences between group means after first adjusting the scores on the dependent variable to remove the effect of covariate, so that the results more precisely reflect the effect of an intervention. The adjustment uses regression procedures. In essence the first step in ANCOVA is the same as the first step in hierarchical multiple regression. Variability in the dependent measure that can be explained by the covariate is removed from further consideration. ANOVA is performed on what remains of Y's variability to see whether, once the covariate is controlled, significant differences between groups means exist.

Post hoc test

Once the F-ratio indicates statistical significance, additional hypothesis tests are done to determine which means are significant and which are not. Post hoc test is used to compare the mean scores at different time interval taken two at a time (pair wise) to assess where a significant mean difference exist.

Results Discussion

Effect of Modified Constraint Induced Movement Therapy on Motor Performance of the upper Extremity (Table 1)

In experimental group, the motor performance of upper extremity, as indicated by the Fugl Meyer Assessment Scores at different stages such as preintervention (1st week), 6th week and 10th week post intervention are respectively 32.1, 45.7 and 61.9.The F value, 3907.58 shows that the variation in physical performance of upper extremity at different interval time is significant at 0.01 level.

The mean difference between initial and 6th week assessment is 13.66, the pair wise comparison with Bonferroni correction shows that the difference is statistically significant at 0.01 levels. It means that, through the intervention the score significantly increased at 6th week when compared with 1st week. The increase in score at 10th week in comparison with 1st week (29.85), and in comparison with 6th week (16.19) is also significant at 0.01 levels.

Thus it can be concluded that motor performance of upper extremity significantly increases with the intervention progressing in experimental group and hence the intervention, modified Constraint Induced Movement therapy is effective in increasing the motor performance of upper extremity **(Table 2) (Figure 1).**

Comparison of Fugl Meyer Assessment scores at 1st week shows no significant variation in the motor performance of the upper extremity among the groups before the intervention. After the intervention, the scores at 6th and 10th week indicates that, the improvement in motor performance of the upper extremity in the experimental group is statistically significant than the control group at 0.01 level (p=0.00).

Effect of Modified Constraint Induced Movement Therapy on daily functions as evidenced by The Barthel Index score

One way repeated measures ANOVA was carried out to assess the effect of Modified Constraint Induced Movement Therapy on Activities of daily living as measured by the Barthel Index score. By using independent "t" test the statistical significance of differences between two group means were identified. As there is significant difference in the mean score of initial assessment between groups, ANCOVA was applied to the Barthel Index scores at 6th and 10th week after correcting for differences in the initial scores **(Table 3).**

In experimental group, the ability to meet the activities of daily living as measured by The Barthel Index scores at different stages such as pre intervention (1st week), 6th week and 10th week post intervention are respectively 40.08, 66.3 and 94.7. The F value, 1288.38 shows that the variation in ability to meet activities of daily living at different interval time is significant at 0.01 level.

The mean difference between initial and 6th week assessment is 25.45, the pair wise comparison with Bonferroni correction shows that the difference is statistically significant at 0.01 levels.

Table 1. Fugl Meyer Assessment Score at Different Intervals One way repeated measures ANOVA.

Fugl Meyer assessment		Mean	SD	N	F#	Pair	Mean Diff.	LS $
Experimental Group	1st week (T1)	32.1	4.9	105	3907.58**	T1 & T2	13.66**	Significant
	6th week (T2)	45.7	4.3	105		T1 & T3	29.85**	Significant
	10th week (T3)	61.9	2.9	105		T2 & T3	16.19**	Significant

Table 2. Comparison of Fugl Meyer Assessment among cases and controls.

	Experimental			Control			T	p
	Mean	Std. Error	N	Mean	Std. Error	N		
1st week	32.09	0.48	105	30.70	0.53	105	1.93	0.055
6th week	45.74	0.42	105	40.50	0.51	105	7.98**	0.000
10th week	61.93	0.28	105	48.48	0.54	105	22.06**	0.000

Comparison of Motor performance of Upper Extremity between groups by Fugl Meyer Assessment

Table 3. Barthel Index Scores at Different Intervals (One way repeated measures ANOVA).

		Mean	SD	N	F#	Pair	Mean Diff.	LS $
Experimental	1st week (T1)	40.8	12.9	105	1288.38**	T1 & T2	25.45**	Significant
	6th week (T2)	66.3	12.7	105		T1 & T3	53.86**	Significant
	10th week (T3)	94.7	8.0	105		T2 & T3	28.41**	Significant

Effect of Modified Constraint Induced Movement Therapy on Daily functions

Table 4. Comparison of The Barthel Index Score between groups.

	Experimental			Control			T	p
	Mean	Std. Error	N	Mean	Std. Error	N		
1st week	40.81	1.26	105	35.76	0.88	105	3.28**	0.001
6th week	66.26	1.24	105	47.90	1.14	105	10.91**	0.000
10th week	94.67	0.78	105	64.33	1.23	105	20.76**	0.000

Comparison of daily functions between groups by Using Barthel Index

Table 5. Comparison of the Barthel Index Score between Groups (ANCOVA).

Stage		Mean ± SD	df	F	P
1st week (pre)	Experimental	40.8 ± 12.9	(1,208)	10.79**	0.001
	Control	35.8 ± 9			
6th week (Post)	Experimental	66.3 ± 12.7	(1,208)	119.12**	0.000
	Control	47.9 ± 11.7			
Adjusted 6th week	Experimental	64.4 ± 0.9	(1,207)	130.37**	0.000
	Control	49.8 ± 0.9			
Adjusted 10th week	Experimental	93.5 ± 0.9	(1,207)	455.94**	0.000
	Control	65.5 ± 0.9			

It means that, through the intervention the score significantly increased at 6th week when compared with 1st week. The increase in score at 10th week in comparison with 1st week (53.86), and in comparison with 6th week (28.41) is also significant at 0.01 levels **(Tables 4 and 5) (Figure 2).**

The above table and figure depict that the mean Barthel Index score indicating the ability to meet activities of daily living increased from 40.81 to 94.67 in the experimental group, when compared to 35.76 to 64.33 in the control group. As there is significant variation of initial scores at the pretest level, Analysis of covariance was applied to 6th and 10th week scores. From the table 4.16 it is clear that the improvement in the ability to meet activities of daily living after the intervention is significantly more in the experimental group than the control group (p=0.000).

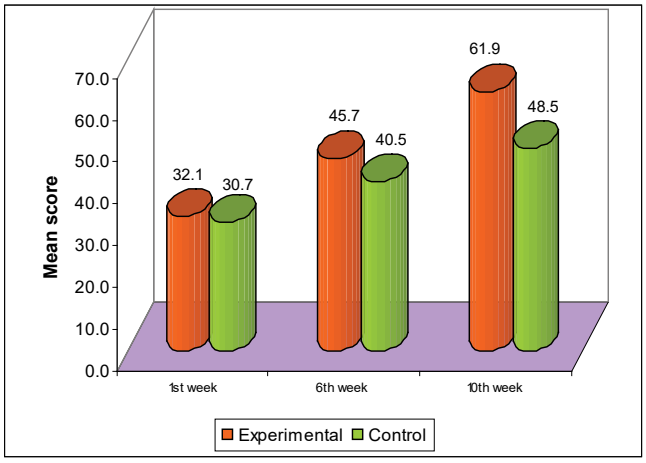

Figure 2 Comparison of Fugl Meyer Assessment among cases and controls.

Effect of Modified Constraint Induced Movement Therapy On Fine Motor Movements As Evidenced By Action Research Arm Test Score

The fine motor movements of the hand are assessed by using the Action Research arm Test. It is scored on a four level ordinal scale. There are four sub tests for the assessment: Grasp, grip, pinch and gross movement. Analysis of each subtest and the whole score was done to find out the individual and total relationship of modified Constraint Induced Movement Therapy with the fine motor movements of the hand. Here also one way repeated measures ANOVA was carried out to find out the effect

of Modified Constraint Induced movement therapy on fine motor movements of the hand. Independent "t" test was used to for testing the statistical significance of differences between two group means. ANCOVA was also used if there was significant differences in the initial mean score was present to determine whether the difference in the scores truly reflect the effect of intervention in the experimental and control groups.

Effect of Modified Constraint Induced Movement Therapy on Grasp (Table 6)

The fine motor movements especially grasp function of the hand in the experimental group at different stages such as pre intervention (1st week), 6th week and 10th week post intervention are 7.7, 11.8 and 17.2 respectively. The F value, 2193.92 shows that after the intervention significant improvement had occurred in the grasp function of the hand **[12].**

The mean difference between initial and 6th week assessment is 4.14, the pair wise comparison with Bonferroni correction shows that the difference is statistically significant at 0.01 levels. The increases in score at 10th week in comparison with 1st week (9.51), and in comparison with 6th week (5.37) are also significant at 0.01 levels **(Table 7) and (Figure 3).**

Comparison of grasp score between groups shows that the mean grasp scores of the experimental group increased from7.66 to11.80 at 6th week and to 17.17 at 10th week. From the result it is clear that increase in the fine motor movements of the hand is significantly more in the experimental group when compared to the control group (p=0.000).

Effect of Modified Constraint Induced Movement Therapy on Grip (Table 8)

In experimental group, the fine motor movements of the hand as indicated by the grip sub scale scores of the Action Research Arm test, at different stages such as pre intervention (1st week), 6th week and 10th week post intervention are respectively 4.9.8.2 and11.4. The F value, (1821.25) shows that the variation in grip

Table 6. Grasp score of ARAT at different intervals (one way repeated measure ANOVA).

		Mean	SD	N	F#	Pair	Mean Diff.	LS $
Experi mental	1st week (T1)	7.7	1.7	105	2193.92 **	T1 & T2	4.14**	Significant
	6th week (T2)	11.8	2.0	105		T1 & T3	9.51**	Significant
	10th week (T3)	17.2	0.9	105		T2 & T3	5.37**	Significant

Table 7. Comparison of Grasp score between groups.

	Experimental			Control			T	p
	Mean	Std. Error	N	Mean	Std. Error	N		
1st week	7.66	0.16	105	7.46	0.20	105	0.77	0.442
6th week	11.80	0.20	105	9.57	0.23	105	7.41**	0.000
10th week	17.17	0.09	105	11.98	0.23	105	21.39**	0.000

Comparison of grasp movements of the hands among the groups

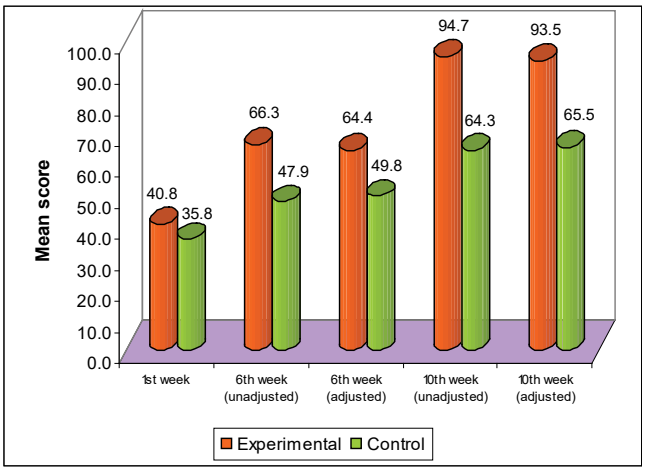

Figure 3 Comparison of Barthel Index Scores between groups (ANCOVA).

Table 8. Effect of Modified Constraint Induced Movement Therapy on Grip Score.

		Mean	SD	N	F#	Pair	Mean Diff.	LS $
Experi mental group	1st week (T1)	4.9	1.3	105	1821.25 **	T1 & T2	3.29**	Significant
	6th week (T2)	8.2	1.3	105		T1 & T3	6.44**	Significant
	10th week(T3)	11.4	0.8	105		T2 & T3	3.15**	Significant

sub scale score at different interval time is significant at 0.01 level **[13-15].**

The mean difference between initial and 6th week assessment is 3.29, the pair wise comparison with Bonferroni correction shows that the difference is statistically significant at 0.01 levels. It means that, through the intervention the score significantly increased at 6th week when compared with 1st week. The increases in score at 10th week in comparison with 1st week (6.44), and in comparison with 6th week (3.15) are also significant at 0.01 levels. From the above results it is clear that modified constraint induced movement therapy produced significant improvement in the fine motor movements of the hand especially the grip function of the hand **(Table 9) (Figure 4).**

Comparison of grip scores between experimental and control groups showed significant improvement of grip function in the experimental group at 6th week (t=7.8) and at 10th week (t=17.29, p=0.000) than the control group.

Effect of Modified Constraint Induced Movement Therapy on Pinch movements of the hand (Table 10)

The Pinch sub scale score of Action research Arm Test indicating fine motor movement function of the hand at different stages such as pre intervention (1st week), 6th week and 10th week post intervention are 7.6, 11.8 and16.6 respectively. The F value, 1277.56 shows that the variation in pinch sub scale score at different interval time is significant at 0.01 levels **[16].**

The mean difference between initial and 6th week assessment is 4.15, the pair wise comparison with Bonferroni correction shows that the difference is statistically significant at 0.01 levels. It means that, through the intervention the score significantly increased at 6th week when compared with 1st week. The increases in score at 10th week in comparison with 1st week (8.96), and in comparison with 6th week (4.81) are also significant at 0.01 levels **[17]** (**Table 11) (Figure 5).**

The maximum possible score for the pinch subscale of ARAT is 18. The pinch score of the experimental group increased from 7.60 to11.75 at 6th week (t=7.7) and to16.56at 10th week (t=20.52) **[18].** It depicts that the improvement in the pinch function of the hand in the experimental group is significant at 0.01 level (p=0.000).

Effect of Modified Constraint Induced Movement Therapy on Gross movement (Table 12)

The gross movement function of the hand in experimental group, at different stages such as pre intervention (1st week), 6th week and 10th week post intervention are respectively 3.4, 6.0 and 8.9. The F value, 1950.44 indicates that that the variations in gross

Table 9.Comparison of Grip Score between groups.

	Experimental			Control			t	p
	Mean	Std. Error	N	Mean	Std. Error	N		
1st week	4.91	0.13	105	4.90	0.13	105	0.05	0.958
6th week	8.20	0.13	105	6.75	0.14	105	7.8**	0.000
10th week	11.35	0.08	105	8.61	0.14	105	17.29**	0.000

Comparison of Grip movements of the hand among the groups

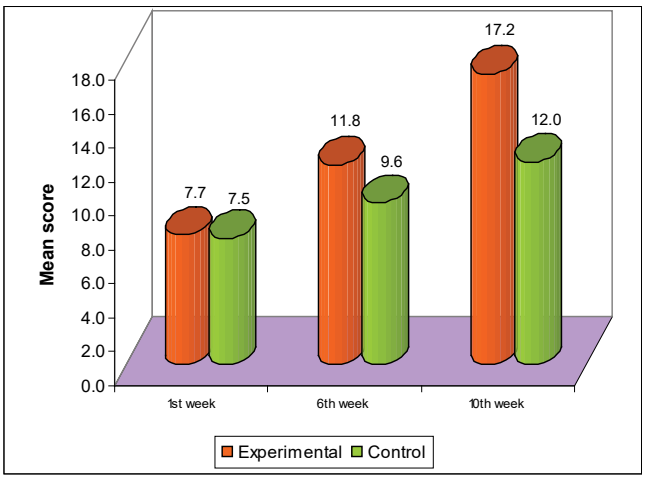

Figure 4 Comparison of grasp score between groups.

Table 10. Effect of Modified Constraint Induced Movement Therapy on Pinch.

		Mean	SD	N	F#	Pair	Mean Diff.	LS $
Experimental	1st week (T1)	7.6	2.0	105	1277.56 **	T1 & T2	4.15**	Significant
	6th week (T2)	11.8	1.8	105		T1 & T3	8.96**	Significant
	10th week (T3)	16.6	1.4	105		T2 & T3	4.81**	Significant

Table 11. Comparison of Pinch score between groups.

	Experimental			Control			t	p
	Mean	Std. Error	N	Mean	Std. Error	N		
1st week	7.60	0.19	105	7.22	0.21	105	1.35	0.178
6th week	11.75	0.18	105	9.57	0.22	105	7.7**	0.000
10th week	16.56	0.13	105	11.70	0.20	105	20.52**	0.000

Comparison of Pinch Movements of the hand between the groups

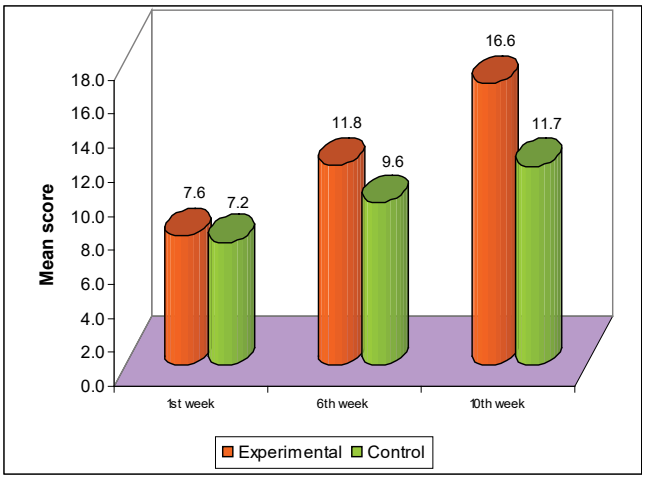

Figure 5 Comparison of Pinch score between groups.

Table 12. Effect of Modified Constraint Induced Movement Therapy on Gross movement.

		Mean	SD	N	F#	Pair	Mean Diff.	LS $
Experimental	1st week (T1)	3.4	1.0	105	1950.44**	T1 & T2	2.64**	Significant
	6th week (T2)	6.0	0.6	105		T1 & T3	5.5**	Significant
	10th week(T3)	8.9	0.6	105		T2 & T3	2.87**	Significant

Table 13. Comparison of Gross movement between groups.

	Experimental			Control			T	p
	Mean	Std. Error	N	Mean	Std. Error	N		
1st week	3.36	0.09	105	3.12	0.06	105	2.17*	0.031
6th week	6.00	0.06	105	4.18	0.13	105	12.66**	0.000
10th week	8.87	0.06	105	5.90	0.11	105	23.39**	0.000

Comparison of Gross Movements of the hands between groups

Table 14. Comparison of effectiveness of intervention in experimental group over control group on Gross movement (ANCOVA).

Stage		Mean ± SD	df	F	p
1st week (pre)	Experimental	3.4 ± 1	(1,208)	4.70*	0.031
	Control	3.1 ± 0.6			
6th week (Post)	Experimental	6 ± 0.6	(1,208)	160.19**	0.000
	Control	4.2 ± 1.4			
Adjusted 6th week	Experimental	6 ± 0.1	(1,207)	153.41**	0.000
	Control	4.2 ± 0.1			
Adjusted 10th week	Experimental	8.8 ± 0.1	(1,207)	534.77**	0.000
	Control	5.9 ± 0.1			

movement function of the hand at different interval time is significant at 0.01 level **[19-22].**

The mean difference between initial and 6th week assessment is 2.64, the pair wise comparison with Bonferroni correction shows that the difference is statistically significant at 0.01 levels. It means that, though the intervention the score significantly increased at 6th week when compared with 1st week. The increases in score at 10th week in comparison with 1st week (5.5), and in comparison with 6th week (2.87) are also significant at 0.01 levels. **(Table 13, and 14), (Figure 6).**

The above table and figure depict that the mean gross movement score increased from 3.36to 8.87 in the experimental group, when compared to 3.12 to 5.90 in the control group. As there is significant variation in the initial pretest scores between the groups, Analysis of covariance (ANCOVA) was applied to 6th and 10th week scores. From the table 4.25 it is clear that the improvement in gross movement function after the intervention is significantly more in the experimental group (p=0.000) **[23-25].**

Effect of Modified Constraint Induced Movement Therapy on Fine motor Movements of the hand (Table 15)

In experimental group, the fine motor movements of the hand as indicated by the Action Research Arm test Assessment Scores at different stages such as pre intervention (1st week), 6th week and 10th week post intervention are respectively 23.5, 37.7and 54.The F value, (4662.31) shows that the variation in fine motor movements of the hand at different interval time is significant at 0.01 level.

The mean difference between initial and 6th week assessment is 14.21, the pair wise comparison with Bonferroni correction shows that the difference is statistically significant at 0.01 levels. It means that, through the intervention the score significantly increased at 6th week when compared with 1st week. The increases in score at 10th week in comparison with 1st week (30.44), and in comparison with 6th week (16.23) are also significant at 0.01 levels **[26].**

Thus it can be concluded fine motor movements of the hand significantly increases with the intervention progressing in experimental group and hence the intervention, modified Constraint Induced Movement therapy is effective in increasing the fine motor movements of the hand **(Figure 7) (Table 16).**

In experimental group the Action Research Arm test score increased from 23.52 to 37.73 at 6th week and to 53.96 at the 10th week. From the result it is clear that fine motor movements of the hand increased significantly in the experimental group (p=0.000) **[27, 28].**

From all the results it can be concluded that even though both the treatment increases motor performance and daily functions of the stroke patients, Modified Constraint Induced Movement Therapy is significantly more effective than the standard therapy offered in the hospital.

Table 15. Effect of Modified Constraint Induced Movement Therapy on Action research arm test score.

		Mean	SD	N	F#	Pair	Mean Diff.	LS $
Experimental	1st week (T1)	23.5	4.6	105	4662.31 **	T1 & T2	14.21**	Significant
	6th week (T2)	37.7	4.1	105		T1 & T3	30.44**	Significant
	10th week (T3)	54.0	2.4	105		T2 & T3	16.23**	Significant

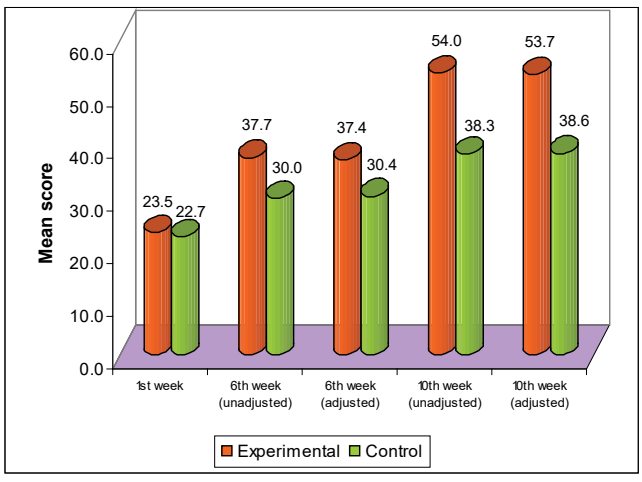

Figure 6 Comparison of effectiveness of intervention in experimental group over control group on Gross movement (ANCOVA).

Table 16. Comparison of action research arm test score between groups.

	Experimental			Control			T	p
	Mean	Std. Error	N	Mean	Std. Error	N		
1st week	23.52	0.45	105	22.74	0.52	105	1.14	0.255
6th week	37.73	0.40	105	30.05	0.59	105	10.85**	0.000
10th week	53.96	0.24	105	38.31	0.57	105	25.42**	0.000

Comparison of Fine motor movements between the groups

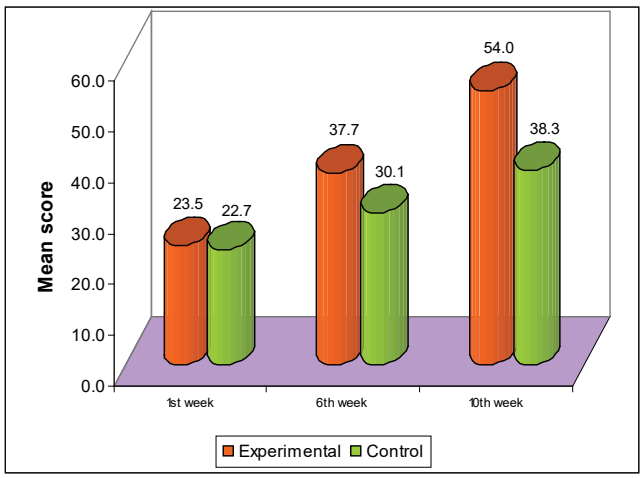

Figure 7 Comparison of Action research arm test scores between groups.

Conclusion

From the study it was found that Modified Constraint Induced Movement Therapy was very effective in improving the motor performance of the upper extremity, fine motor movements of the hand such as grasp, grip, pinch and gross movement and daily functions in stroke patients. Both basic and clinical researches are critical in improving rehabilitation of stroke patients. Evidence based practice throughout the path of health care delivery system offers a new and challenging way for the health care delivery persons.

References

1 Albert SJ, Kesselring J Neurorehabilitation of Stroke. J Neurol 1-16.

2 Amanda C, Fuzaro Carlos T, Guerreiro Fernanda C, Galetti Renata B V M (2012) Araujo Brazilian Journal of Physical Therapy 16:2 .

3 American (2010) Heart Association Heart and Stroke Statistical Update.

4 Askim T, Indredavik B, Vangberg T, Håberg A (2009) Motor network changes associated with successful motor skill relearning after acute ischemic stroke: a longitudinal functional magnetic resonance imaging study. Neurorehabil Neural Repair 23:295-304.

5 Chan DY, Chan CC, Au DK (2006) Motor relearning programme for stroke patients: a randomized controlled trial. Clin Rehabil 20:191-200.

6 Ching-yi Wu, Hsish-ching Chen, I-Husan Chen (2007) Effects of modified constraint induced movement therapy on movement kinematics and daily functions in patients with stroke. Clinical Rehabil 21:1075-1086.

7 Ching-yi Wu ScD, Chia-ling Chen, Wen-chung Tsai, Keh-chung Lin (2007) A Randomized Controlled Trial of Modified Constraint-Induced Movement Therapy for Elderly Stroke Survivors: Changes in Motor Impairment, Daily Functioning, and Quality of Life. Arch Phys Med Rehab 88:273.

8 Secondandary Stroke Prevention Continuum (2011). Minneapolis Minn 17:1213-32.

9 Fritz SL, Light KE, Patterson TS (2005) Active finger extension predicts outcomes after constraint-induced movement therapy for individuals with hemiparesis after stroke. Stroke 36:1172-1177.

10 Grotta J C, Noser E A, Ro T, Boake C, Levin H et al. (2004) Constraint-induced movement therapy. Stroke 35:2699-2701.

11 Grotta J (2004) Constraint-induced movement therapy. Stroke 35:2699-2701.

12 Haynes MP, Phillips D (2012) Modified Constraint Induced Movement Therapy enhanced by a Neuro-Development Treatment-based therapeutic handling protocol: Two case studies. J Pediatr Rehabil Med 5:117-24.

13 Kim DG, Cho YW, Hong JH, Song JC, Chung HA (2008) Effect of constraint-induced movement therapy with modified opposition restriction orthosis in chronic hemiparetic patients with stroke 23:239-44.

14 Kim Y, Park J, Ko M, Jang S, Lee, P (2004) Plastic changes of motor network after constraint induced movement therapy. Yonsei Med J 54:241-246.

15 Kitago T, Liang J, Huang VS, Hayes S, Simon P et al. (2012) Improvement After Constraint-Induced Movement Therapy: Recovery of Normal Motor Control or Task-Specific Compensation? Neurorehabil Neural Repair 23.

16 Kunkel A, Kopp B, Muller G, Villringer K, Villringer A et al. (1999) Constraint-induced movement therapy for motor recovery in chronic stroke patients. American Academy of Physical Medicine and Rehabilitation 80:624-628.

17 Liepert J, Miltner W H R, Bauder H, Sommer M, Dettmers C et al.(1998) Motor cortex plasticity during constraint-induced movement therapy in stroke patients. Neuroscience Letters 250:5-8.

18 Lin KC, Wu CY, Wei TH, Grung C, Lee CY, Liu JS (2007) Effects of modified constraint induced movement therapy on reach to grasp movements and functional performance after chronic stroke. A randomized controlled study. Clin Rehabil: 21:1075-1086.

19 Mark VW, Taub E, Morris DM (2006) Neuroplasticity and constraint-induced movement therapy. Eura Medicophys 42:269-84.

20 Morris (2006) Constraint-induced movement therapy: characterising the intervention protocol. Eura medicophys 42:257-68.

21 Nijland R, Kwakkel G, Bakers J, van Wegen E (2011) Constraint-induced movement therapy for the upper paretic limb in acute or sub-acute stroke: a systematic review. Int J Stroke 6:425-33.

22 Page S (2008) Modified constrain-induced therapy in chronic stroke: results of a single-blinded randomized controlled trial. Physical Therapy 88:333-340.

23 Page S, Sisto S, Levine P, McGrath R (2004) Efficacy of modified constraint induced movement therapy in chronic stroke: A single-blinded randomized controlled trial. Arch Phys Med Rehabil 85:14-18.

24 Siebers A, Oberg U, Skargren E (2010) The effect of modified constraint-induced movement therapy on spasticity and motor function of the affected arm in patients with chronic stroke. Physiother Can Fall 62:388-396.

25 Sirtori V, Corbetta D, Moja L, Gatti R (2009) Constraint-induced movement therapy for upper extremities in stroke patients.Cochrane Database Syst Rev: CD004433.

26 Taub E, Crago JE, Uswatte G (1998) Constraint-induced movement therapy: a new approach to treatment in physical medicine. Rehabil Psychol 43:152–170.

27 Treger I, Aidinof L, Lehrer H, Kalichman L (2012). Modified constraint-induced movement therapy improved upper limb function in subacute post stroke patients: a small-scale clinical trial. Top Stroke Rehabil 19:287-93.

28 Winstein CJ, Miller JP, Blanton S (2003) Methods for a multisite randomized trial to investigate the effect of constraint-induced movement therapy in improving upper extremity function among adults recovering from a cerebrovascular stroke. Neurorehabil Neural Repair 17:137–152.