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EFFECTS OF VIRTUAL REALITY TRAINING (VRT) WITH MODIFIED CONSTRAINT-INDUCED MOVEMENT THERAPY (m-CIMT) ON HAND FUNCTION IN ACUTE STROKE SUBJECTS. A RANDOMIZED CONTROL TRIAL

Neurophysiotherapy

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ABSTRACT

Background And Purpose: The use of VR training has increased the potential for motor learning and neuroplasticity during hand rehabilitation. m-CIMT enhances the use and skill of the paretic hand in daily life by improving the motor function. The purpose of this study was to evaluate the effectiveness of Virtual Reality Training (VRT) with Modified constraint-induced movement therapy (m-CIMT) on hand function in acute stroke subjects. **Methodology:** 30 acute stroke subjects who met inclusive criteria with MMSE 24 or > 24 and Brunnstrom's motor stage of hand recovery ≥ 4 were selected by using the lottery method. Subjects were randomly allotted to Group-A 15(experimental) and Group-B 15(control) after getting written consent from the subjects. Group-A received VRT along with m-CIMT, while Group-B received only m-CIMT hand function training. The study was conducted for a total of 12 sessions over 4 weeks. Pre-test and post-test evaluation of hand function done by using the Jebsen Taylor Hand Function Test (JTHFT) and Box and Block Test (BBT). **Results:** Pre-test and post-test values of JTHFT and BBT within the experimental and control groups showed statistically significant improvement ($p< 0.001$). But comparatively, mean ± SD difference is greater in the experimental group than in control group. **Discussion:** This study revealed that integrated VRT with m-CIMT on hand function training in acute stroke subjects showed more improvement than Existing VRT and m-CIMT alone by increasing cortex representation and resulting in brain reorganization. **Conclusion:** Results of the study concluded that integrated VRT with m-CIMT hand function training shows more improvement in the recovery of hand function in acute stroke subjects than in m-CIMT.

KEYWORDS

Stroke; Hand Function; Virtual Reality; Modified Constraint-Induced Movement Therapy, Jebsen Taylor Hand Function Test, Box and Block test

INTRODUCTION

Stroke is a significant health issue worldwide. According to the latest Global Burden of Disease (GBD) 2019 report, stroke is still the second most common cause of death globally and the third leading cause of both death and disability combined. Globally, approximately one in every four individuals aged 25 and above will experience a stroke at some point in their lives.

In India Crude incidence of stroke ranged from 108 to 172/100,000 people per year, and crude prevalence from 26 to 757/100,000 people per year.[1] It is estimated that 80% of stroke patients have upper limb deficits and have decreased activity and use of the paretic hand in daily life.[2]

The hand serves the purpose of communication, expression of emotions, and manipulation of the environment. The hand executes the commands given by the brain through neurons that travel through the nervous system to the respective areas such as muscles to articulate certain body parts. Restrictions on daily living and social activities in patients with stroke lead to a decrease in their quality of life and self-esteem.

The neural mechanisms underlying the recovery of hand function are complex, and interdependent, and occur at different periods after the onset of stroke. Most of the functional recovery after diagnosis occurs in the first three months, although neural repair processes and behavioural improvements continue to show slight plasticity in later phases of the rehabilitation process.

Various therapies based on a conventional approach have been demonstrated to be useful, achieving good results in terms of hand rehabilitation such as motor imagery training, Mirror therapy, constrained induced movement therapy (CIMT), m-CIMT, Repetitive task training bilateral training, electrical stimulation's, VR training.

Among them, VR is a therapeutic approach that has been used in the field of rehabilitation in recent years. VR is a computer-based, interactive, real-time multi-sensory simulation environment, which generates a virtual environment that may activate multiple systems (visual, proprioceptive, action-observation, etc.).

In this approach, users interact with virtual objects through the movements of their hands and body, The use of VR has increased the potential for motor learning and neuroplasticity during rehabilitation. "VRT utilizes mirror neurons as the basis for its neurological foundation." [3] A study using magnetic resonance imaging found consistent results, showing a reorganization of the sensorimotor cortex. [4]

m-CIMT focuses on intensive, gradual training of the paretic upper limb to improve its use in specific tasks, limit the use of the less affected upper limb, and, in the context of behaviour-changing methods for improving adherence, transfer the clinical achievements into the patient's real-life by relating the therapeutic intervention components to the improvement of motor function and the use and skill of the paretic hand in daily life.

NEED OF THE STUDY

Systematic reviews suggest that virtual reality-based upper extremity training improves function and daily living activities in chronic stroke patients. Various studies show the effects of m-CIMT on hand function show positive results in acute stroke subjects.

A preliminary study done on the Effects of virtual reality training with modified constraint-induced movement therapy on upper extremity function in acute-stage stroke shows that virtual reality training combined with modified constraint-induced movement is effective for upper extremity function recovery in acute stroke subjects done in small sample size (n=3). [5]

As per the literature, there are few studies available on the combined effects of VRT and m-CIMT improving hand function in acute-stage stroke subjects. To fill this gap, the present study was conducted to evaluate the effectiveness of VRT training with m-CIMT on hand function in acute stroke subjects.

AIM OF THE STUDY

To evaluate the effectiveness of Virtual Reality Training (VRT) with Modified constraint-induced movement therapy (m-CIMT) on hand function in acute stroke subjects.

OBJECTIVES OF THE STUDY

- To determine the effectiveness of VRT and m-CIMT on hand function in acute stroke subjects by using box and block tests in the

experimental group.
- To determine the effectiveness of m-CIMT on hand function in acute stroke subjects by using box and block tests in the experimental group.
- To determine the effectiveness of VRT and m-CIMT on hand function in acute stroke subjects by using the Jebsen- Taylor hand function test in the control group.
- To determine the effectiveness of m-CIMT on hand function in acute stroke subjects by using the Jebsen- Taylor hand function test in the control group.

METHODOLOGY

Study Set Up And Duration:
Subjects with stroke from the Neurology intermediate ward, Neurology general ward, College of Physiotherapy in Sri Venkateswara Institute of Medical Sciences and SV Ayurvedic College, Tirupati were recruited in the study. The study was conducted between March to November 2023

Materials
- VRT kit
- Constraining tool**-** Arm pouch
- Box and block test tool kit
- Jebsen Taylor hand function test tool kit
- Chair
- Stopwatch
- Marbles
- 4 plastic glasses
- Plank
- Pen, Pencil, Mouse, Book, Anti-slip mat.
- Checkers, Pegboard, Table.

Informed Consent:
The study protocol was explained to the subjects and written informed consent was collected after getting willingness from the subjects/ relatives (subjects who were not able to give consent) were included in the study.

Study Design: Randomized control trial.

Sampling Technique: Simple random sampling technique.

Randomization Method: lottery method.

Sample Size: 30: GroupA-15(Experimental group); GroupB-15 (Control group).

Inclusion Criteria
- Subjects older than 18 years, who had their first ischemic stroke.
- Subjects with hemodynamically stable were included.
- The diagnosis of all the patients with defined and confirmed by neuroimaging (MRI and CT scan).
- Subjects with Mini-mental examination scores greater than or equal to 24.
- Subjects with Brunstrom motor stage of hand recovery ≥ 4.
- Subjects Able to lift two fingers with the forearm pronated on the table or to extend the wrist at least 10 degrees from a fully flexed position**.**

Exclusion Criteria
- Subjects who are unable to provide their consent were excluded.
- Subjects with a history of transient ischemic stroke.
- Subjects with a Previous history of brain neurosurgery or epilepsy.
- Subjects with sensory abnormalities.
- Subjects who are not suitable for MRI (including but not limited to metal fragments in eyes or face; Implantation of any electrical devices such as cardiac pacemakers, cardiac defibrillators, cochlear implants or cochlear nerve stimulators, brain or skull abnormalities).
- Subjects with wrist Fracture and wounds over the hand were excluded.
- Subjects with severe cardiovascular and pulmonary diseases

Methods
30 acute stroke subjects who met inclusive criteria with MMSE 24 or > 24 and Brunnstrom's motor stage of hand recovery ≥ 4 were included in the study. Subjects were assigned randomly to Group-A 15 and Control group-B 15 after getting written consent from the subjects. Group-A received VRT along with m-CIMT, while Group-B received only m-CIMT hand function training. The study was conducted for a total of 12 sessions over 4 weeks. Pre-test and post-test evaluation of hand function following was evaluated by using the JTHFT and BBT.

VRT Procedure
- Virtual Reality training was given by using the Leap Motion-based virtual reality system, which consisted of two parts, a personal computer and the Leap motion controller. The two parts were connected through a USB cable. [6]
- The controller can track, with sub-millimetre accuracy, the movement of multiple hands and fingers. The captured images of a hand were converted into digital format and projected onto the screen of the personal computer. [6] The subject was able to watch a virtual representation of their hand and perform tasks in virtual games by controlling the avatar through hand-arm coordination in the real world. This allowed the participants to fully engage themselves in the virtual environment. [6]
- The subject was made to sit comfortably in a chair in front of a desk equipped with personal computer and motion controller equipment after constraining unaffected upper extremities with an arm pouch.
- Then, the subject was instructed to perform warm-up hand movements first so that the controller could recognize the movement of the affected hand in a straight-back position.
- VRT training includes a Petal picking game, a Robot assembly game, a Block stacking game, a Piano playing game, and a Block making game.

m-CIMT Procedure
- This procedure, known as m-CIMT, is based on the EXPLICIT-stroke program. During each training session, patients wear an arm pouch on their unaffected hand and are required to use their more affected limb for at least 3 hours per day. The arm pouch restricts the ability to use the unaffected hand during most tasks.
- m-CIMT training includes a series of hand-on-table exercises, cylindrical grip exercises, grasp exercises, pinch exercises, and the marble exercise. [7]

Experimental Group
- Training started after baseline evaluation by using JTHT and BBT.
- The Subjects in the experimental group received VRT hand function training along with m-CIMT hand function training.
- VRT intervention was given by Leap motion controller device for 30 minutes once a day, every alternative day in a week, for 4 weeks.
- Followed by, subjects in the experimental group received m-CIMT hand function training 30 minutes once a day, every alternative day in a week, for 4 weeks.
- The unaffected upper extremity in the experimental group was limited to 3 hours a day.

Control Group
- Training started after baseline evaluation by using JTHT and BBT.
- The Subjects in the control group received modified-constraint-induced movement therapy only.
- Subjects in the control group received m-CIMT hand function training 30 minutes once a day, every alternative day in a week, for 4 weeks.
- The unaffected upper extremity in the control group was limited to 3 hours a day.

Treatment Protocol
Table-1: Intervention Protocol For Both Experimental Group And Control Group

S. No.	Duration	Experimental group VRT+ m-CIMT	Control group (m- CIMT)
1	Number of weeks	4 weeks	4 weeks
2	Number of sessions in a week	3 sessions	3 sessions
3	Session time	30 minutes- VRT+30 minutes- m- CIMT	60 minutes
4	Total number of hours	12 hours	12 hours
5	Constraint time	3 hours per day	3 hours per day

STATISTICAL ANALYSIS AND RESULTS

Statistical Analysis, Data collected were statistically processed using Microsoft Xcel Windows 2019 version and analysed by using SPSS 21 version. For the general characteristics of the study participants, the mean and standard deviation were calculated using descriptive statistics. A paired t-test was used to examine changes in hand function before and after the intervention in the experimental and control groups.

1. Participants' Characteristics: The general characteristics of the subjects who participated in the experiment are as follows.

A total of 30 subjects participated in this study; 15 participants in the experimental group underwent virtual reality training along with m-CIMT hand function training and 15 participants in the control group received only m-CIMT. No significant difference was found between the two groups according to the participant's sex, age, stroke type, side of stroke, or time since stroke onset ($p > 0.05$).

2. Comparison of changes in hand function in the experimental group.

In the experimental group, the JTHFT score before and after the intervention improved from 190.8 ± 87.82 to 147.66 ± 66.48, showing a significant difference ($p < 0.001$).

In the experimental group, the BBT score before and after the intervention improved from 31.13 ± 8.70 to 47.33 ± 7.99, showing a significant difference ($p < 0.001$).

3. Comparison Of Changes In Hand Function In The Control Group.

In the control group, the JTHFT score before and after the intervention improved from 172 ± 65.04 to 154 ± 59.34, and a significant difference was found ($p < 0.001$).

In the control group, the BBT score before and after the intervention improved from 31.73 ± 5.69 to 40.73 ± 6.39, and a significant difference was found ($p < 0.001$).

4. Comparison Of Changes In Hand Function Between Groups Before And After Intervention.

Changes in hand function between the two groups before and after intervention are as follows.

Pre-test and post-test values of JTHFT and BBT within the experimental and control groups showed statistically significant improvement ($p< 0.001$). But comparatively, comparatively mean ± SD difference is greater in the experimental group than control group.

Table-2: Comparison Of Changes In Hand Function Between The Experimental Group And Control Group

Group	Test	Mean	SD
Group-A	JTHFT	147.66	66.48
	BBT	47.33	8.7
Group-B	JTHFT	154	59.34
	BBT	40.73	6.39

DISCUSSION

This study aims to evaluate the effectiveness of virtual reality (VRT) with modified Constraint-Induced Movement Therapy (m-CIMT) on hand function in acute stroke subjects.

A total of 30 subjects participated in the study and randomly 15 subjects were assigned to the experimental group and the other 15 were assigned to the control group. The experimental group received VRT along with m-CIMT hand function training, while the control group received m-CIMT hand function training only.

According to this study, both experimental and control groups showed significant improvement, but the comparatively experimental group showed better significance. Thereby null hypothesis was rejected.

In the JTHFT evaluation, the fine motor skills of the hand were significantly improved in the experimental group compared to the control group. In BBT evaluation, the gross dexterity of the hand was significantly improved in the experimental group compared to the control group. These results suggested that VRT training along with m-CIMT hand function training could facilitate the recovery of motor function and dexterity of the affected hand. This study was supported by A systematic review, Hao et al. found that virtual reality can lead to improved clinical outcomes, such as enhanced motor function, through various neurophysiological changes like improved interhemispheric balance, cortical connectivity, mapping, and activation. [8] Supporting this physiological change, a study using magnetic resonance imaging found consistent results, showing a reorganization of the sensorimotor cortex. [4]

A preliminary study done on the Effects of virtual reality training with modified constraint-induced movement therapy on upper extremity function in acute-stage stroke shows that virtual reality training combined with modified constraint-induced movement is effective for upper extremity function recovery in acute stroke patients. [5]

A recent study done on the effect of Kinesio taping combined with virtual reality-based upper extremity training on upper extremity function and self-esteem in stroke subjects shows ($p<0.05$) in the combined intervention group. It that combined intervention was more effective at improving upper extremity function than existing VRT intervention. [9]

Results of this study showed that integrated VRT with m-CIMT on hand function training showed mild improvement to Existing m-CIMT alone on improving gross and fine motor skills of the hand and in terms it improves the quality of life.

CONCLUSION

The results of this study suggest that integrated VRT along with m-CIMT hand function training and m-CIMT hand function training alone are both effective at improving hand function in acute stroke subjects.

However, these results suggested that integrated VRT with m-CIMT are therapeutically more effective than the m-CIMT hand function training alone in subjects with acute stroke.

Limitations Of The Study

- Small sample size it is difficult to generalize the population.
- Difficulty in ascertaining the continuity of the treatment.
- Not specifying hand, type of stroke, and age group, and gender.

Future Recommendations

- Conduct large group studies.
- Prospective studies are needed to evaluate the continuity of the effects over time.
- Studies can be conducted on hand-specific, stroke-specific, gender-specific, and age group-specific.

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