RESEARCH ARTICLE

EFFECT OF CONSTRAINT- INDUCED MOVEMENT THERAPY ON UPPER EXTREMITY RECOVERY AMONG PATIENTS WITH HEMIPLEGIA

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Abstract

Stroke results in upper motor neuron dysfunction that produces hemiplegia or paralysis of one side of the body, most of the stroke survivors experience weakness and loss of function in the affected arm and hand. This limits their ability to perform daily activities independently. Constraint-Induced Movement Therapy (CIMT) is a well-established neurorehabilitation approach designed to overcome learned non-use by restraining the unaffected limb and encouraging intensive use of the affected one. The Fugl-Meyer Assessment for Upper Extremity (FMA-UE) is a reliable and validated tool used to assess motor function recovery after stroke. It measures various components such as movement, coordination, and reflex activity in the affected upper limb. Evaluating the effect of CIMT on upper extremity recovery using FMA-UE helps determine its effectiveness in improving wrist and hand function, which are essential for performing fine motor tasks.

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Introduction:-

WHO defines stroke as "an Acute neurological dysfunction of vascular origin with symptoms and signs corresponding to the involvement of focal areas of the brain. Hemiplegia is a neurological condition caused by stroke, traumatic brain injury or other neurological damage, usually manifesting as weakness or paralysis on one side of the body. It causes significant motor impairment, spasticity, imbalance and perceptual deficits. The impact of hemiplegia extends poor coordination and sensory deficits on the affected side, further limiting their mobility and independence. Severely affected individuals have loss of ADL function, imposing a substantial burden on families and society. Individuals with hemiplegia experience partial to complete loss of voluntary movement on the affected side of the body. Depending on the lesion site, other associated difficulties such as speech impairment, cognitive decline and emotional disturbances may also be present. A multidisciplinary rehabilitation approach—including Occupational therapy, physiotherapy, speech therapy WITH medical management improves overall quality of life.

Constraint Induced Movement Therapy (CIMT)
CIMT is a rehabilitation approach designed primarily to improve the function of a weakened upper limb in individuals with neurological injury or other conditions causing hemiplegia. The early work was conducted by Dr. Edward Taub, a behavioural neuroscientist. He demonstrated that animals with impaired limbs often stopped using the weak limb due to "learned non-use". This is a behavioural phenomenon where individuals rely solely on the

unaffected limb even when partial motor ability still exists in the affected limb. Taub discovered that by restraining the unaffected limb & forcing the use of the weaker limb, animals were able to regain functional movement over time. In early 1990s, Taub and colleagues translated their laboratory findings into human stroke rehabilitation. In 1999, the First Stroke Rehabilitation Evidence-Based Randomized Trial (EXCITE Trial) provided strong scientific validation that CIMT was more effective than conventional therapy for improving real-world upper-extremity use. This study contributed to the integration of CIMT into rehabilitation guidelines in the United States, Europe, and Asia.

CIMT consists of two main components: restriction of the unaffected limb and intensive, structured training of the affected limb. The unaffected upper limb is typically restrained using sling, or splint for 90% of waking hours, compelling the patient to use the affected hand during daily activities. For the affected limb, treatment involves task-oriented practice for 3–6 hours per day, usually over a period of 2–3 weeks, depending on the protocol. Training incorporates "shaping", in which tasks are progressively graded in difficulty based on the individual's performance, and repetitive task practice, where meaningful functional activities like grasping, reaching, lifting, and manipulating objects are performed repeatedly. Feedback, encouragement, and goal-setting are used to enhance patient motivation and self-efficacy. CIMT involves home practice assignments, daily activity logs, real-life task simulations, and monitoring to ensure that improvements transfer to daily living situations. Over time, the combined effect of constraint, intensive practice, shaping, and behavioural transfer techniques results in significant improvement in functional ability, motor control, and real-world usage of the affected upper limb. CIMT induces cortical reorganization in the motor cortex, leading to improved motor function.

Introduction to Sling Use in CIMT
The sling is one of the primary physical restraint devices used in Constraint-Induced Movement Therapy (CIMT). It is applied to restrict the non-affected upper limb, thereby compelling the patient to use the affected limb. Restraining the less-affected arm is a core element of CIMT protocols and helps to overcome learned non-use.

Purpose of the Sling
The sling aims to:
1. Limit compensatory use of the stronger arm.
2. Promote spontaneous, functional use of the affected limb.
3. Reduce habitual movement patterns that reinforce learned non-use.
4. Increase the intensity of motor practice by forcing use of the impaired arm during daily activities.

Description of the Sling
The sling provides full upper limb restriction, including the shoulder and elbow joints.

It is considered the strongest form of restraint, as it prevents compensatory movements from the entire affected arm. Because of this restriction, the sling is associated with better long-term retention of functional gains, since it forces the patient to rely more heavily on the affected limb during therapy.

The sling is designed to:
1. Immobilize the entire less-affected upper extremity.
2. Restrict shoulder and elbow movement.
3. Prevent the stronger limb from assisting in functional tasks.
4. Limit reaching, grasping and weight-bearing activities of the non-affected limb.

According to CIMT protocols:
1. The sling is worn for 90% of waking hours.
2. Removed only during sleep.
3. Removed for a ½ hour exercise period daily.

Use caution in patients with:
1. Balance problems (risk of falls).
2. Wheelchair users who rely on both arms for stability or mobility.
3. Tasks requiring two-handed safety (cooking, transfers, etc.).

Research has shown that mCIMT effectively improves motor control, functional use of the affected limb, and participation in daily activities while offering a more flexible, patient-centred rehabilitation model.

FUGL–MEYER ASSESSMENT FOR UPPER EXTREMITY (FMA–UE) Developed by Fugl-Meyer et al., (1975), this Assessment is a stroke-specific, performance-based test used to evaluate motor function, balance, sensation, and joint functioning in hemiplegic patients.

Review Of Literature:-

1. Choi and Kim (2024) conducted a systematic review and meta-analysis on the effect of constraint-induced movement therapy (CIMT) in post-stroke patients with hemiplegia. The review included 34 randomized controlled trials and assessed outcomes using the Fugl-Meyer Assessment for Upper Extremity (FMA-UE), Action Research Arm Test, and other functional measures. The results showed that CIMT was more effective than conventional rehabilitation in improving upper limb motor function, reducing impairment, and enhancing activities of daily living. The authors concluded that CIMT is particularly useful for patients with some preserved wrist and finger extension and can be considered an efficient therapy for improving distal upper extremity function after stroke.

2. Damayanti Sethy et al., (2016) conducted a comparative study on chronic stroke patients to evaluate the effectiveness of Modified Constraint Induced Movement Therapy (mCIMT) and Bilateral Arm Training. Sixty patients were divided into two groups, each receiving respective interventions. Outcome measures included Fugl-Meyer Motor Assessment (FMA-UE), Action Research Arm Test (ARAT) and Motor Evoked Potentials. The study concluded that both interventions improved motor function, but mCIMT demonstrated superior improvement in functional use of the affected hand, indicating that mCIMT may be a more efficient rehabilitation strategy.

3. Raj Kumar Yadav et al., (2016) conducted a randomized controlled trial titled "Efficacy of Modified Constraint Induced Movement Therapy in the Treatment of Hemiparetic Upper Limb in Stroke Patients." The study evaluated the effectiveness of mCIMT compared to conventional therapy in stroke survivors with hemiparesis. Patients in the mCIMT group showed significantly greater improvement in motor function of the affected upper extremity after 4 weeks of intervention. The study concluded that modified CIMT is an effective rehabilitation approach for improving overall upper limb motor recovery, and it can be recommended as a clinical intervention for post-stroke patients.

4. Gert Kwakkel et al., (2015) reviewed the effects of constraint-induced movement therapy (CIMT) after stroke. Their findings showed that both original and modified forms of CIMT significantly improve upper limb motor function, arm-hand activities, and self-reported use of affected limb in daily life. The review also reported that the effectiveness of CIMT does not depend on the type of protocol, timing, or intensity of treatment, but patients need to have some voluntary wrist and finger extension to benefit most. The study concluded that CIMT is a well-supported intervention to enhance functional recovery of the paretic upper limb.

5. Mah M. Fathalla (2014) conducted a study to evaluate the efficacy of modified constraint-induced movement therapy (mCIMT) in acute stroke patients. The participants were assessed using the Fugl-Meyer Motor Assessment and the Action Research Arm Test before and after treatment. The results showed that patients receiving modified CIMT achieved greater improvements in upper limb motor function compared to those receiving conventional rehabilitation. The study concluded that mCIMT is an effective method to promote motor recovery in acute stroke patients.

6. Aimee P. Reiss (2012) presented a review article on Constraint-Induced Movement Therapy: Current Perspective and Future Directions. The author discussed how CIMT addresses learned non-use by restricting the unaffected limb and encouraging repetitive use of the affected arm. The review also identified limitations, such as patient selection and intensity requirements, and suggested that modified CIMT protocols and home-based applications may improve feasibility. The author concluded that CIMT is a well-established, evidence-based intervention and future research should focus on tailoring protocols to individual needs and increasing accessibility in clinical practice.

7. Steven L. Wolf (2008) conducted the EXCITE randomized trial to evaluate the retention of upper limb function in stroke survivors who received constraint-induced movement therapy (CIMT). Participants with mild to moderate upper limb impairment were randomized to receive CIMT or usual care. Assessments included the Wolf Motor Function Test and the Fugl-Meyer Assessment (FMA-UE) at baseline, post-treatment, and at long-term follow-up. The study found that improvements in motor function achieved through CIMT were retained for up to two years after intervention. The author concluded that CIMT produces lasting benefits in motor recovery and functional use of the paretic upper limb in stroke survivors.

Methodology:-

This study provides evidence on the effectiveness of CIMT among patients with hemiplegia who obtains Occupational therapy service at Government Cuddalore Medical College& Hospital, Chidambaram.

Aim of Study:-

"To evaluate the effectiveness of Constraint-Induced Movement Therapy (CIMT) on upper extremity motor recovery in patients with hemiplegia, as measured by the Fugl-Meyer Assessment for Upper Extremity (FMA-UE)".

Objectives:-

* To understand how hemiplegia, affects motor control and functional movement of the upper extremity.
* To assess the sensorimotor function of the upper extremity using the "fugl - meyer assessment - upper extremity"
* To assess the motor recovery patients with hemiplegia using the Fugl Meyer Assessment – Upper Extremity Scale.
* To implement Constraint – Induced Movement Therapy techniques to enhance upper extremity motor function in hemiplegia patients.
* To compare pre and post intervention FMA -UE scores to determine the effectiveness of CIMT in improving upper extremity motor function.

Method of Study:-

This study adopted a **True experimental study design** using pre-test post- test control group method. **20 post stroke subjects** (40-60 years) satisfying the selection criteria were taken for the study. Participants were randomly assigned to an experimental group (n=10) receiving constraint induced movement therapy based occupational therapy treatment & a control group (n=10) receiving routine occupational therapy treatment. Informed consent was obtained from the subjects after detailed explanation about the study.

Outcome measure included the Fugl Meyer Assessment -Upper Extremity performance-based test used to evaluate upper extremity motor function in stroke patients.

The study is conducted at Department of Occupational Therapy, Division of Physical Medicine Rehabilitation, Government Medical College & Hospital, Cuddalore district.

Sample of study

A total of **20** participants were assigned to experimental and control groups using simple randomization techniques. Simple randomization was implemented through a computer – generated random number sequence to ensure unbiased group allocation. The allocations result as an experimental group of 10 participants receiving constraint induced movement therapy based occupational therapy training and a control group of 10 participants receiving routine occupational therapy care only.

Inclusion Criteria:-

1. First-time occurrence of CVA with hemiplegia.
2. No excessive pain in the affected limb
3. No major cognitive deficit
4. Active wrist extension of at least 20 degrees, and 10 degrees of active extension of MCP
5. Ability to move the affected arm 45 degree of shoulder flexion and abduction, and 90 degrees of elbow flexion and extension

Exclusion Criteria:

Patient with shoulder subluxation or Cognitive deficits, or Co-morbid history of other neurological deficits are excluded.

Intervention Details:
Informed Consent:
The purpose and procedure of the study were clearly explained to each participant. Confidentiality was assured. Those willing to participate provided written consent. Caregivers signed the consent form on behalf of participants who were unable to provide a signature, with the patient's knowledge.

Unaffected upper extremity of the patient was constrained by sling. The arm was secured , which was then fastened around the neck. Patient was advised to use the restraint for 5 hours that was considered as the time of frequent use and asked to keep a record of the time period worn.

Screening and Baseline Assessment:
The assessment was taken using the FUGL MEYER ASSESSMENT – UPPER EXTREMITY SCALE (FMA-UE). Patients who scored within the mild to moderate range were selected for intervention. A control group of participants, received Occupational therapy services without the above said intervention.

Task-Oriented Training of the affected limb
Participants in study group received intensive, repetitive, goal-directed practice focusing on motor recovery. Training included:
1. Reach, grasp, lift, and release activities
2. Pinch and grip strengthening tasks
3. Object manipulation (pegs, cones, balls, sponges)
4. Fine-motor tasks such as turning pages, buttoning simulators, and picking up small objects

Shaping Technique
1. Tasks were graded progressively according to the patient's performance.
2. The difficulty level was adjusted to maintain challenge and promote continuous improvement.
3. Verbal feedback and reinforcement were provided to enhance motivation.

Repetitive Task Practice
1. Functional activities were practiced repeatedly to facilitate motor relearning.
2. Activities included grasp–release training, wrist extension tasks, and hand coordination activities.

To promote real-life use of the affected limb:
Home practice recommendations, daily activity logs, encouragement to use the affected limb during simple ADLs (e.g., holding a cup, brushing hair)

Data analysis and Result
Twenty individuals participated, with 10 allocated to the intervention (CIMT) group and 10 to the control group. Age of participant in the intervention group ranged from 40 to 60 years, while the control group ranged from 44 to 60 years , indicating broadly comparable middle aged samples.

Affected side distribution
Descriptive statistics
Upper extremity motor function was assessed using the Fugl Meyer Assessment (FMA UE) before and after the intervention period. At baseline, mean FMA UE scores were similar across groups: 87.9 ± 5.15 in the intervention group and 86.7 ± 5.48 in the control group, suggesting comparable initial motor status. After the intervention, CIMT group showed marked improvement, with a mean FMA UE of 101.4 ± 4.77, corresponding to a mean gain of 13.5 ± 0.53 points (range 13–14). In contrast, the control group showed a modest increase to 89.8 ± 5.83, with a mean gain of 3.1 ± 0.57 points (range 2–4). The descriptive pattern therefore suggests considerably greater motor recovery in the CIMT group than in the control group.

Measure	Intervention mean ± SD	Control mean ± SD
FMAUE pre	87.9 ± 5.15	86.7 ± 5.48
FMAUE post	101.4 ± 4.77	89.8 ± 5.83
Change (post–pre)	13.5 ± 0.53	3.1 ± 0.57
Change range (min–max)	13–14	2–4

Inferential statistics
(within group changes)
Paired samples t tests compared pre & post intervention FMA UE scores within each group. In the CIMT group, there was a highly significant improvement, t (9) = 81.00, p = 3.37×10^{-14}, corresponding to a mean increase of 13.5 points. The control group also demonstrated a statistically significant but smaller improvement, t (9) = 17.27, p = 3.30×10^{-8}, with a mean increase of 3.1 points. These findings indicate that both routine care and CIMT were associated with gains in motor function, but **gains with CIMT were far larger.**

Withingroup paired t tests for FMAUE

Group	Pre mean ± SD	Post mean ± SD	Mean change	t (df=9)	p value
Intervention	87.9 ± 5.15	101.4 ± 4.77	13.5	81.00	p < 0.001
Control	86.7 ± 5.48	89.8 ± 5.83	3.1	17.27	p < 0.001

Between group comparison of change
Between group differences were evaluated using an independent samples t test (post–pre), with unequal variances allowed. The CIMT group improved on average 10.4 points more than the control group, t (17.90) = 42.46, p = 2.01×10^{-19}, indicating an extremely significant treatment effect favouring CIMT. Effect size was estimated using Cohen's d, yielding d ≈ 18.99, which is far beyond conventional thresholds for a "large" effect and reflects both the minimal within group variability and the substantial mean difference in change. Although such a large value partly arises from the unusually homogeneous gains in each group, it quantitatively underscores the superiority of CIMT in this dataset.

Betweengroup t test and effect size for FMAUE change

Outcome	Intervention (mean ± SD)	Control (mean ± SD)	Mean difference	t (df≈17.90)	p value	Cohen's d
FMAUE change (post–pre)	13.5 ± 0.53	3.1 ± 0.57	10.4	42.46	p < 0.001	18.99

Ancova
To account for any minor baseline differences and increase statistical precision, an analysis of covariance (ANCOVA) was performed with post intervention FMA UE as the dependent variable, group (CIMT vs control) as the fixed factor, and baseline FMA UE as covariate. The model showed a highly significant effect of group, F(1,17) = 1683.41, p = 1.91×10^{-18}, confirming that, after adjusting for baseline scores, participants receiving CIMT had substantially higher post intervention FMA UE scores than controls. Baseline FMA UE also emerged as a significant covariate, F (1,17) = 1591.39, p = 3.07×10^{-18}, indicating that initial motor status strongly predicted post intervention scores. The residual error term in the ANCOVA was very small, reflecting the low within group variability in post treatment FMA UE once baseline and group were accounted for. These ANCOVA results reinforce the t test findings, demonstrating that the observed superiority of CIMT is not attributable to baseline imbalances in motor function.

Result:-

This trial of 20 stroke survivors (10 CIMT, 10 control) found that both groups were comparable in age and side affected. The demographic data indicate that the two groups were broadly similar in age and side of involvement. CIMT produced markedly superior upper extremity motor recovery compared with usual care. Baseline FMAUE scores were similar, but the CIMT group improved by an average of 13.5 points versus 3.1 points in controls, with both withingroup changes and the betweengroup difference highly significant (p < 0.001) and associated with an extremely large effect size. Nonparametric tests and ANCOVA adjusting for baseline FMAUE confirmed the robustness of these findings, indicating that CIMT leads to substantially greater functional gains than conventional management alone. Descriptively, participants receiving CIMT achieved much larger gains in FMA UE scores than those receiving usual care, and these gains were consistent across individuals within the intervention group.

Conclusion:-

(CIMT) significantly improved upper extremity motor function in selected participants compared to routine Occupational Therapy. The intervention group showed greater gains in FMA-UE scores Also, the study highlights feasibility of CIMT in a government hospital setting, supporting its wider adoption in resource-limited

environments. Patient adherence and tolerance remain challenges. Overall, the findings strengthen the evidence base for CIMT as a standard rehabilitation approach in stroke care.

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