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Review Article

Physiotherapy Section

Effectiveness of Constraint-induced Movement Therapy on Hand Function in Cerebral Palsy Children: A Narrative Review

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ABSTRACT

A neurodevelopmental disease known as Cerebral Palsy (CP) first manifests in infancy and affects a variety of developing abilities, including motor control, coordination, tactile perception, cognition, and attention. The most prevalent type, accounting for 60%-70% of cases, is spastic CP. Ataxic CP accounts for 10%-15%, athetoid CP for 10%-15%, and mixed CP for 10%. Children diagnosed with hemiplegia exhibit firmness and muscle weakness due to unilateral involvement of both upper and lower limbs on the opposite side of the brain lesion. These variables may manifest upper limb motor deficits, such as restricted grasp, reach, and manipulation. These disabilities result in functional restrictions during daily activities and may cause the affected extremity to be underutilised. Hand impairment in hemiplegic CP occurs from damage to the motor cortex and corticospinal pathways, which are in charge of fine motor control of the fingers and hand. In terms of enhancing fine motor abilities and improving functional results, it has been demonstrated that Constraint-induced Movement Therapy (CIMT) is useful for individuals with CP. CIMT involves teaching a child to use their affected hand by using a constraint on the unaffected hand and repetitive extensive implementation of movements with the affected hand. The aim of the present review was to find out how CIMT affected the hand functionality in children with CP.

Keywords: Hand impairment, Hemiplegia, Neurodevelopmental disease

INTRODUCTION

A non progressive anomaly in the developing brain causes a variety of mobility and postural impairments collectively known as CP. This static motor impairment develops during the perinatal, postnatal, and antenatal stages. It can lead to several disorders such as mental retardation, learning disabilities, feeding, speech, and behavioural issues, as well as vision and hearing defects, seizures, and mental retardation [1]. Research has indicated that the prevalence of CP varies between 1.5 and 4 per 1000 live births or children worldwide [2]. CP occurs in different forms, such as spastic, athetoid, and ataxic. A total of 30% of these cases are spastic hemiplegic. Individuals suffering from spastic hemiplegia display recognisable signs of muscle weakness, spasticity, and paralysis in the affected arm, leg, or trunk. This leads to mobility abnormalities that often impact one side of the body more severely [3]. One of the main factors preventing people with hemiplegic CP from performing their regular tasks is impaired hand function. Hand impairments are frequently caused by injury to the motor cortex and corticospinal pathways, which control the fine motor control of the hand and fingers [4]. This undermines the independence and quality of life of these children since they typically have significant difficulties performing tasks, particularly two-handed activities, with the affected upper limb [5]. Impaired hand function restricts the participation of children with hemiplegia in educational, leisure, and vocational roles, although they can attend regular school due to proper intellectual capacity [6]. Recent studies suggest that proper practice can improve the motor performance of children with CP. In order to treat people with restricted Upper Extremity (UE) movements, a novel approach called CIMT is employed in physical rehabilitation where activities are provided for practice [4]. Through this technique, the individual is forced to use the affected limb while the unaffected or less affected limb is confined [7]. Researchers noticed improved function in adults, so they adapted this adult treatment technique to be used with children with CP who presented with an asymmetrical motor impairment. Dr. Taub and colleagues developed CIMT, which was first introduced in the 1990s to treat adults who had suffered a stroke. Beneficial effects of CIMT on cortical reorganisation in adult stroke patients have been reported. Adults with the impaired side reported improvements in their hand function and motor control. Improved movement efficiency and quality in the affected hand were also noted in studies conducted on children with hemiplegic CP [8].

The CIMT technique consists of a method involving restraints on the sound limb using a glove, splint, and sling in hemiplegic patients. To enhance the limb's capability, the patient is encouraged to utilise the affected limb as much as possible, frequently, and under supervision. This therapy provides maximum repetition in everyday activities, improving performance and encouraging brain neuronal plasticity. The important factors of CIMT are the duration of constraint and the overall environment, which decides its effectiveness in patients with CP [9]. The strategy for regaining mobility based on the brain's neurological flexibility is therapeutic limitation, followed by enhanced upper limb function with increased participation [10]. Literature suggests that various treatment techniques are used for the rehabilitation of upper limb function in CP patients. The focus is usually given more on improving upper limb function rather than hand function. Compared to other rehabilitation therapies, CIMT significantly improved hand function, ultimately enhance the quality of life. Therefore, the goal of this review is to determine whether CIMT is beneficial in assisting children with CP to regain hand function.

Effectiveness of CIMT Treatment

Morris DM et al., identified three primary components of the original CIMT therapy procedure: 1) Repetitive, task-oriented exercise of the more impaired upper limb for six hours a day, for 10 consecutive weekdays; 2) A package of adherence-enhancing behavioural techniques designed to transfer the improvements made in the clinical setting to the patient's real-world environment; and 3) Constraining the less impaired upper limb to encourage the use of the more impaired upper limb during 90% of the waking hours [11]. According to Morris DM et al., Modified CIMT (mCIMT) is based on three principles: first, a "transfer package" that ensures upper limb use in the patient's daily life; second, repeated training of the

impaired upper limbs for a few hours over 10 workdays; and third, limited use of the unaffected upper limb, which forces the individual to utilise the more impaired upper limb [12]. Modified CIMT (mCIMT) involves the same principles as CIMT (i.e., restraint of the unaffected UE and practice of functional activities of the affected extremity), but with less intensity than traditional CIMT.

Search engine strategies are used for selecting articles from databases such as Google Scholar, Cinahl, Semi-automatic Ground Environment (SAGE), PubMed from 2011 to 2023. A total of 30 articles are selected for review, where CIMT was compared with other interventions and found to be effective in 21 articles, while nine articles were rejected [Table/Fig-1] [1,3,4,6,8,9,13-27].

DISCUSSION

In a randomised trial, Gordon AM et al., stated that improvements in hand function associated with CIMT are due to restraining the affected hand because the restraint allows the therapist to focus more on the affected hand. The outcomes indicate that hand function can be enhanced by rigorous, progressive, task-specific training [28]. Wallen M et al., interpreted in the study that Modified Constraint-Induced Therapy is effective for enhancing the performance of daily living tasks or upper limb function in children with hemiplegic CP, and it is possible to apply in a variety of service delivery contexts and is acceptable to the majority of families [13]. The hand function and ADL performance of children who underwent mCIMT were

S. No.	Author	Total patients	Age group	Type of CP	Intervention	Outcome measures	Conclusion
1.	Wallen M et al., (2011) [13]	50	Between 18 mnth and 8 y	Spastic hemiplegic CP	Modified Constraint-Induced Therapy (mCIMT) vs intensive occupational therapy	Canadian Occupational Performance Measure (COPM), goal attainment scaling, assisting hand assessment, paediatric motor activity log, Modified Ashworth Scale, Modified Tardieu Scale, and a parent questionnaire	The two interventions yielded similar outcomes.
2.	Xu K et al., (2011) [14]	68	2 to 14 y	Hemiplegic CP	Occupational treatment group, CIMT group, and CIMT plus electrical stimulation group	Active Range of Motion (ROM), grip strength, nine-peg hole test, UE functional test, Peabody Developmental Motor Scales (PDMS), globe rating scale, and social life ability scale	After six months of treatment, the UE functional test scores and visual-motor integration scores of PDMS improved at a higher rate in the constraint therapy plus electrical stimulation group than in the other two groups.
3.	Choudhary A et al., (2012) [6]	31	3-8 y	Hemiplegic CP	mCIMT with conventional therapy vs conventional therapy	Quality of UE Skills Test (QUEST) and nine-hole peg board	mCIMT is effective in improving upper limb function in hemiplegic CP.
4.	Yu J et al., (2012) [3]	24	9.4 y	Hemiplegic CP	Modified Constraint-induced Movement Therapy (mCIMT)	Box and Block Test (BBT) for arm dexterity and hand manipulation ability, hand dynamometer for grip strength and Wee-functional Independence Measure (WeeFIM) for ADL	Significant improvement in dexterity, grip strength and ADL on affected side.
5.	Rohrer UH et al., (2012) [8]	1	4y 9 mnth	Spastic quadriplegia	CIMT	Paediatric Evaluation of Disability Inventory (PEDI)	Significant improvements were made by the individual in his play behaviour, communication, functional skills, and self-care.
6.	Rostami HR et al., (2012) [15]	32	6y 2 mnth to 11y 8 mnth	Spastic hemiparetic CP	4 groups CIMT, Virtual Reality (VR), CIMT+Virtual Reality (VR), Control	Paediatric motor activity log, Bruininks-oseretsky test	Incorporating Virtual Reality (VR) and CIMT may improve upper limb functioning of children with hemiparetic CP.
7.	Thakkar P (2014) [16]	10	2-8 y	Spastic hemiplegic Cerebral Palsy (CP)	Modified constraint induced movement therapy	PMAL, QUEST	Children with CP benefit with mCIMT in terms of both motor function and functional use of the afflicted UE.
8.	Chorna O et al., (2015) [17]	216	12-24 mnth	CP and typically developing child	CIMT with motor – sensory training	Bimanual Fine Motor Function scale (BFMF), Event-Related Potential (ERP), Kinematics of reach, Bayley Scales of Infant Development (BSIDIII)	CIMT is effective for sensory and motor impairments in CP.
9.	Sankar UG (2015) [1]	10	3-5 y	Static hemiplegic CP	CIMT	QUEST scale (Quality of UE skills test)	CIMT effectively improve UE function in hemiplegic CP.
10.	Zafer H et al., (2015) [9]	20	Between 1.5 and 12 y	Spastic hemiplegic CP	CIMT group and BMT group	QUEST scale (Quality of UE skills test)	Significant improvement in grasp and dissociated movement is noted in CIMT group. Therefore, for unilateral disorders, CIMT appears to be the best treatment strategy, whereas BMT is regarded to be better for bilateral conditions.
11.	Shanmugam SN and Bhojan K, (2015) [4]	10	8-12 y	Hemiparetic Cerebral Palsy (CP)	Modified CIMT	Paediatric motor activity log, box and block	Remarkable gains in gross manual dexterity of box and block and functional assessments of PMAL. Consequently, children with hemiparetic CP can benefit from modified CIMT as a therapeutic strategy to enhance their gross hand dexterity and upper limb functional abilities.

12.	Eliasson AC et al., (2017) [18]	37	3-8 mnth	High risk of developing unilateral CP	Baby CIMT Vs baby massage	Hand Assessment for Infants (HAI), Assisting Hand Assessment (AHA), the Parenting Sense of Competence Scale (PSCS)	Young children with unilateral CP benefit from baby-CIMT in terms of their unimanual abilities.
13.	Tadvi D and Rajagopalan V (2018) [20]	1	2.5 y	Hemiplegic CP	CIMT	QUEST, AHA	CIMT is feasible in improving quality of upper limb movement in a child with CP.
14.	Rahman E et al., (2018) [19]	12	2-8 y	Hemiplegic CP	Modified CIMT with conventional physiotherapy treatment	QUEST and Paediatric Motor Activity Log (PMAL)	Modified CIMT yields clinically as well as statistically significant improvements in both motor function and functional use of the affected UE in hemiplegic CP.
15.	Palomo-Carrión R et al., (2020) [21]	8	4-8 y	Hemiplegic CP	Modified CIMT	QUEST, Shriners Hospital for Children Upper Extremity Evaluation (SHUEE), hand dynamometer and goniometer	mCIMT increased the UE functionality of children diagnosed with congenital hemiplegia.
16.	Bansal A and Diwan S (2021) [22]	26	2-10 y	Spastic hemiplegic CP	Group-A received Hand Arm Bimanual Intensive Training (HABIT), while Group-B received Modified Constraint Induced Movement Therapy (MCIMT)	QUEST and COPM	Both Hand Arm Bimanual Intensive Training (HABIT) and Modified Induced Movement Therapy (MCIMT) are beneficial for enhancing UE skill quality and occupational performance.
17.	Jain T et al., (2021) [23]	20	4-8y	Hemiplegic CP	Group-A: mCIMT and Conventional Treatment Group-B: HABIT and traditional treatment Group-C: traditional treatment	QUEST	mCIMT is more effective in improving quality of UE function in hemiplegic CP.
18.	Harini K et al., (2022) [24]	20	4-8 y	Spastic hemiplegic CP	Group-A: CIMT Group-B: Play therapy	BBT and Motor Activity Log Scale (MAL)	Improvement in hand function in Group-A.
19.	Roberts H et al., (2022) [25]	15	5-15 y	Unilateral CP	Group based Paediatric CIMT	Assisting Hand Assessment (AHA)	Improvement in hand function from repeat doses of pCIMT in children with Unilateral CP.
20.	Bakhat W et al., (2022) [26]	44	5-12 y	Spastic hemiplegic CP	Experimental group: regular physical therapy and expanded CIMT, and traditional group: regular physical therapy	Paediatric motor activity log scale and Wolf motor function test	Experimental group shows improvement in hand function in Spastic hemiplegic CP.
21.	Shih TY et al., (2023) [27]	29	5-12 y	Unilateral CP	Kinect-based CIMT and Therapist-based CIMT	Unimanual reach-to-grasp task, 6-camera motion capture system, PMAL-R	On Upper Extremity (UE) motor control and everyday motor function, the effects of CIMT based on Kinect are similar to those of CIMT based on therapists. Additional advantages of the Kinect-based CIMT include enhanced trunk motor control.

[Table/Fig-1]: Effectiveness of CIMT treatment [1,3,4,6,8,9,13-27].

markedly enhanced. A randomised controlled trial conducted by Jaeho Y et al., proves that patients' dexterity and grip strength on the impaired side improve after mCIMT training. The study also indicates that mCIMT needs to be taken into account in a variety of clinical contexts and would be useful to develop children's interest in various mCIMT training activities [3]. A study by Rohrer UH et al., concluded that a child with CP had significant improvement in play habits, speech, functional skills, and self-care. The child's ability to bear restraint, maintain motivation, and exhibit a special will to learn, focus, and finish tasks were the reasons for the progress [8]. Xu K et al., stated that for children with hemiplegic CP, the combination of electrical stimulation and CIMT is probably the most effective way to improve hand performance. A total of 68 children with hemiplegic CP participated in this trial and were divided into three groups at random: occupational treatment, constraint therapy, and constraint therapy plus electrical stimulation. Children with CP who received both electrical stimulation and restriction therapy demonstrated a higher rate of improvement in their hand function after six months of treatment [14]. Rostami HR et al., have suggested that CIMT practices in a virtual environment have shown significantly beneficial effects in children with spastic hemiplegic CP. In this randomly allocated, controlled, single-blinded experiment, 32 participants were allocated into four groups i.e., a virtual reality group, a CIMT group, a CIMT with virtual reality group, and a control group [15].

The PMAL was used as a measurement tool to assess children's upper limb performance at home, and the Bruininks-Oseretsky Test of Motor Proficiency (BOTMP) was used to assess hand function. The results of the research suggest that children who participated in training sessions that included modified CIMT in a virtual setting improved more than those who received modified CIMT, VR, or traditional movement therapies in terms of quantity, quality, and speed of movement of the affected limb. DeLuca SC et al., conducted a study to compare the effects of two dosage levels, i.e., moderate and high dosages of CIMT for hemiplegic CP, and found that both dosages produced positive effects on outcome measures. Using the same CIMT intervention approach at three clinical sites and a variety of outcome measures with strong reliability and validity data for the study population, this work offers the first direct comparison of two dosage levels. The lack of variations between the dosing groups was confirmed by the results [29]. Thakkar P et al., concluded that modified CIMT in children with hemiplegic CP demonstrates the value, safety, and efficacy of therapies. By using

massed practice to encourage patients to use their more damaged limb, CIMT causes a use-dependent functional restructuring of brain regions. Modified CIMT is a practical and acceptable intervention for children with hemiplegic CP, as the study further demonstrates [16]. Chorna O et al., stated that for adults and older children with CP, one of the few successful neuro-rehabilitation methods that has been demonstrated to enhance UE motor function is CIMT. When determining which children will benefit most from CIMT compared to other levels of therapy, the relationship between the severity of CP and the efficacy of treatment may be beneficial [17]. According to Shanmugam SN and Bhojan K, modified CIMT has been shown to be beneficial for upper limb functional activities and gross manual dexterity in CP. The improved motor recovery in hemiplegic patients was attributed to the increased size and shifting of cortical area neural firing after CIMT [4]. Eliasson AC et al., conducted a study to investigate the efficaciousness of baby-CIMT and baby-massage for enhancing the manual skills of infants younger than 12 months with unilateral CP [18]. Participants were randomly assigned to receive either baby-CIMT or baby-massage for two 6-week training periods separated by a 6-week pause. The results indicate that baby-CIMT seems to have a positive impact on the early development of hand function and is beneficial for later development of hand function.

No adverse effects were found for the baby CIMT program, and it was also considered feasible by the parents [30]. Significant differences between pre and post values of all components of QUEST and PMAL (p=0.00) were found in a study by Rahman E et al., assessing the impact of modified CIMT on UE function for children with hemiplegic CP. This suggests that MCIMT is effective in enhancing UE functions and in ADL activities. It is hypothesised that this strategy may work particularly well in children since young children have a greater capacity for central nervous system flexibility than adults do [19]. A single case study by Tadvi D and Rajagopalan V attempts to identify the feasibility of the application of paediatric CIMT on a two and a half-year-old girl with hemiplegic CP who lacks the use of the right upper limb for activities. The intervention was well-accepted by the child and mother when it was integrated as play and counselling for the mother. Parents should be trained to apply the intervention and in the selection of activities appropriate for the child's abilities and how to progress. However, the scores on QUEST, AHA, and disregard index improved. Therefore, CIMT was found to be feasible to be applied within paediatric rehabilitation [20]. A study by Palomo-Carrión R et al., stated that most children with unilateral brain injury have a pathological pattern of grasp for their age which, depending on the level of injury, results in an insufficient synergy of coordination strength of the injured hand. According to the study, parents and children are more likely to accept therapy when the treatment is administered in modest dosages in their homely environment. Therefore, children with congenital hemiplegia were found to be more functional when given a low dose of mCIMT [21]. The study conducted by Jain T et al., suggested that treatment using mCIMT is more effective than HABIT or CT alone in improving the quality of UE function in patients with hemiplegic CP. During CIMT, cortical areas like the primary motor cortex show increased electrical and metabolic neuronal activity. The mCIMT approach is predicated on an active rather than a passive understanding of motor learning, whereby individuals learn by actively seeking to overcome the challenges that are specific to a functional task, as opposed to repeatedly performing their usual movement patterns. Growing evidence points to the fact that adequate practice is the key to triggering progress in function [23].

Children with CP who underwent CIMT were able to dramatically improve their hand function, according to a meta-analysis conducted by Sholikah MA et al., after examining published research. In this technique, repetitive motion exercises are provided to provide movement memory to the child, and these repetitive movements can generate or create new neural pathways in the brain [31]. According to Harini K et al., play therapy is less beneficial than child-friendly CIMT for children with spastic hemiplegic CP. When pre- and post-test data from the BBT as well as the Motor Activity Log Scale were evaluated, it was discovered that the CIMT group's hand function statistically improved more than the play therapy groups in response to treatment [24]. This study confirms that the use of CIMT as a therapy for CP is beneficial in regaining the function of the impaired hand and also proves that CIMT training improves patients' dexterity and grip strength on their affected side [3,12]. In a study by Rostami HR et al., it was suggested that CIMT practices in a virtual environment had shown significantly beneficial effects in children with spastic hemiplegic CP [15]. Some studies suggested that CIMT intervention should include play activities to make the intervention more interesting for the children, and also the duration of constraint should be reduced so that the children will not become irritated and exhausted by the treatment procedure. In this study, the analysis of 21 articles reported the positive effectiveness of CIMT as an intervention. These investigations showed that impaired CP patients' hand function was considerably enhanced by CIMT.

Limitation(s)

The long-term effects of CIMT on hand function in people with CP have only been partially studied and reported. Thus, it is obvious that more research is needed to fully understand the long-term impacts of CIMT.

CONCLUSION(S)

Overall, the benefits of CIMT for children with CP were reviewed in the present analysis of the literature. In order to restore hand function in patients with CP, the recommended course of action is to incorporate CIMT into the treatment regimen. The key findings are that CIMT therapy significantly improves the hand function of CP patients. Moreover, CIMT with virtual reality, play activities, and electrical stimulation has greater advantages over CIMT alone.

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