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# **Effect of hand arm bimanual intensive therapy (HABIT) on gross motor functions in upper extremity of spastic CP**

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**Abstract**---To review studies that can examine whether there's effect of hand arm bimanual intensive training (HABIT) and neurodevelopmental treatment on gross motor function in spastic cerebral palsy. Journal articles published between 2011 and 2021 were secured by searching computerized bibliographical databases. High evidence studies as randomized control trials, systematic reviews and cross sectional studies were included. A total of 30 studies were selected. After analyzing the studies, it was seen that; there is effect of HABIT in upper extremity on gross motor function, functional training, manual dexterity and activities of daily living and NDT was also improved gross motor function, spasticity and strength in upper extremity.

**Keywords**---hand arm bimanual, intensive therapy, gross motor functions.

**Introduction**

Cerebral Palsy is by motor abnormalities accompanied by physical dysfunction and mental disorders. In 2001, 764,000 children and adults in the United States

were diagnosed with Cerebral Palsy. In addition, an estimated 8,000 infants and children suffer from Cerebral Palsy, and 1,200 to 1,500 pre-school children suffered from Cerebral Palsy every year.[1] The spastic type of CP is further categorized into unilateral or bilateral distribution; the dyskinetic and ataxic types are commonly viewed as distributed bilaterally. In the case of a mixed form of CP, the child is classified according to the dominant clinical feature. In spastic CP, some dystonic features are often present, especially when the upper extremities are involved.[5]

the presentation of patients with CP is highly variable, ranging from those with mild neurological deficit to those with severe involvement. The diagnostic matrix to be followed in case of CP includes a detailed history, gait analysis, physical examination of lower limbs, examination of upper extremities and spine, and additional tests for appropriate clinical evaluation. The above diagnostic matrix is an important pillar for decision-making in CP.[2]

Physiotherapy plays a key role in the management of CP and almost all persons diagnosed as cerebral palsy receive physiotherapy services. The goals of physiotherapy are facilitating the participation needs of the child with CP and reducing the physical impairments of the symptoms. Physiotherapy helps children with CP to achieve their maximum potential for physical independence and fitness levels and improve the quality of life of the children and their family by minimizing the effect of their physical impairments. [3]

Previously, a population-based study described the prevalence and nature of upper limb deformities using the Zancolli and House classifications in 277 children with spastic CP, in relation to CP subtypes (Arner et al., 2008). Wrist and finger flexion deformities and thumb-in-palm deformities were noted in children with spastic hemiplegia or quadriplegia, but the relation of these deformities to upper limb function and forearm supination problems was not described and assessed the degree of upper limb deformity using the Gshwind and Tonkin, Zancolli, and House classifications in 21 children with spastic CP and 9 children with other types of CP. They reported that the degree of upper limb deformity was significantly related to upper limb function. Upper limb function has been closely related to gross motor function in children with CP, and this relationship is more evident in bilateral than unilateral CP[18]

Intense upper limb training paradigms such as constraint-induced movement therapy and bimanual training have the strongest evidence for improving upper limb functioning primarily in children with hemiplegia. [4] Treatments targeting upper limb function in children with CP aim to improve functional abilities, promote functional independence, and/or reduce disabling muscle tone. Frequently reported treatments are constraint-induced movement therapy, bimanual training, virtual reality and computer-based training, or combinations of these treatments with intramuscular chemo denervation by botulinum neurotoxin A (BoNT-A). However, current effectiveness studies for upper limb function predominantly focus on children with unilateral spastic CP. For spasticity management in all types including bilateral CP, intramuscular BoNT-A, oral diazepam, or selective dorsal rhizotomy (SDR) have proved to be effective.[5]

### **The State of the Evidence for Intensive Upper Limb Therapy Approaches**

Since the first published randomized controlled trial of constraint-induced movement therapy with children with unilateral cerebral palsy in 2004, there has been a substantial increase in the evidence for this intensive treatment approach. Efficacy of bimanual training (targeting coordinated use of 2 hands together) and models combining constraint-induced movement therapy and bimanual therapy (hybrid therapy) has been investigated to a lesser extent[6] Twenty-four randomized controlled trials have been published for constraint-induced movement therapy (19 studies; n  $\frac{1}{4}$  662); hand arm bimanual intensive training (1 study; n  $\frac{1}{4}$  20); and hybrid therapy (3 studies; n  $\frac{1}{4}$  116) Eight studies of constraint-induced movement therapy, 1 hand arm bimanual intensive training, and 2 of hybrid therapy have compared intervention to a control or usual care group receiving substantially less therapy. Six studies of constraint-induced movement therapy and 2 of hybrid therapy have compared intervention to an equivalent dose of bimanual therapy or usual care.[6]

HABIT focuses on functional activities without the use of restraints, along with concurrent encouragement of bimanual hand use through positive feedback and knowledge of performance. HABIT stresses coordination of both arms by using structured tasks in bimanual play and daily activities. Training is based on motor learning theory (practice specificity, types of practice, and feedback) and neuroplasticity (the potential of the brain to change by repetition, increasing movement complexity, motivation, and reward) through tasks that require the equal use of both arms in bimanual skills.[7] Hand-arm intensive bimanual therapy (HABIT) is a form of bimanual intervention that maintains the intensity and progressive task-specific practice of CIMT, but is performed in the context of bimanual activities (Charles & Gordon, 2006). Randomized clinical trials have demonstrated that HABIT results in improved quality and quantity of bimanual upper extremity use (Gordon et al., 2007, 2008) and is equally effective as CIMT in improving unimanual hand function and spontaneous bimanual hand-use.(gorden et al.)[8]

Constraint-induced movement therapy and hand-arm bimanual intensive therapy (HABIT) are successful therapeutic approaches used to improve the motor actions of children with HCP.<sup>7</sup> These approaches have been effective in improving the affected hand/arm function and bimanual coordination. The cortical changes related to these therapeutic improvements are associated with reorganization of the sensorimotor cortex topology, an increase in white matter volume, and maintenance of the integrity of the corticospinal fiber tract.<sup>8,9</sup> Despite these promising results, these studies have largely overlooked the potential cortical changes associated with the action-planning problems noted in children with HCP[9]

The prefrontal cortex (PFC) plays a critical role in planning and monitoring of motor actions.<sup>1</sup> This notion is based on the outcomes of numerous neuroimaging studies that have demonstrated concurrent activation within the PFC, the dorsolateral prefrontal cortex (DLPFC), and the ventrolateral prefrontal cortex (VLPFC) while performing motor actions. Few neuroimaging studies have evaluated the activity within these cortical regions, as children with HCP plan

their motor actions[9]. Lin et al.9 reported positive effects of a home-based ConstraintInduced Movement Therapy protocol in children with CP. However, their study sample included children with unilateral and bilateral CP.[10]

Bleyenheuft et al. investigated the efficacy of HABIT-ILE in children with bilateral CP. This intervention is a variation of Hand–Arm Bimanual Intensive Therapy (HABIT), designed for children with unilateral CP, which combines bimanual upper extremity training with activities involving the trunk and lower extremities.10 Participants performing HABIT-ILE showed greater improvements in the performance of daily activities, in the dexterity of the dominant hand, and in the achievement of individualized functional goals than a comparison group who maintained usual care.[10]

NDT promotes proprioceptive input and is aimed at reduction of spasticity as well as facilitating normal motor development and improved activities of daily living. NDT focuses on the promotion of normal and suppression of abnormal patterns in motor disturbances caused by central nervous system damage, with the aim of improving posture and movements performed with abnormal muscle tone. NDT is effective in improving the patient’s body alignment and functional level, which normalises posture through key point of control on the patient’s body and handling[11].

Among a variety of traditional interventions, neurodevelopmental treatment has been predominantly used over the years.6,7 The method focuses on establishing normal motor development by facilitating normal sensorimotor components such as muscle tone and reflexes, or by inhibiting abnormal movement patterns to improve functional movement.7–10 The effectiveness of the neurodevelopmental treatment approach has been shown with improvements in motor performance, especially in gross motor ability, postural control, and stability.11–14 However, Bo bath noted that the treatment did not automatically carry over into the activities of daily living, as they had expected it would[12]

## **Materials and Methods**

This is a Literature review study and we have taken the article that was published in various search engines like PubMed, Google scholar. 30 articles were collected out of which 15 were included in study. All 15 studies were of high methodology quality. To identify articles on impact of HABIT and NDT on gross motor function with spastic cerebral palsy. In this study we searched the Medline database using the following keywords: cerebral palsy, hand arm bimanual intensive training(HABIT), neurodevelopmental treatment(NDT), gross motor function, upper extremity. Articles were selected from duration period of 2011-2021. The article was selected on the basis of their abstracts and their reference links were also searched for articles meeting our inclusion criteria and a few of them had been included in this study. The selected articles at least had one intervention used and consists of randomized control trials, systematic reviews and cross-sectional studies. Articles with no clear conclusions were excluded. Articles prior to the year 2010 were also not included in the study, as well as articles with no intervention used in them or of poor level of evidence were also excused from this study.

AUTHORS	OBJECTIVE	METHOD	RESULT
1. ANKITA BANSAL ET AL,2021	Effect of Modified Constraint Induced Movement Therapy and Hand Arm Bimanual Intensive Training on Upper Extremity Skills and Functional Performance in Children with Spastic Hemiplegic Cerebral Palsy	26 participants (age 2-10 years) were matched in regards of age and side of affection to both groups, where subjects in mCIMT group wore a restrictive sling for 6 hours a day and performed repetitive massed practice of unimanual activities with sling: 2 hours per day for 10days. Participants in group HABIT performed intensive bimanual activities for 6 hours a day for 10 days. Outcome measures QUEST and COPM were assessed in both the groups immediately after the intervention and 1 month post intervention	mCIMT and HABIT groups showed significant improvement from the pretest to immediate posttest in the QUEST and COPM (P < .0001) (15.26 - 15.21 for QUEST, 12.64-13.94 for COPM performances and 14.24-14.43 for COPM satisfaction for group A-B respectively) which were maintained after 1 month of intervention. Moreover there was no significant difference between both the group
2. MI-RA KIM ET AL,2016	Effects of combined Adeli suit and neurodevelopmental treatment in children with spastic cerebral palsy with gross motor function classification system levels I and II	Twenty children with CP of Gross Motor Function Classification System levels I and II were randomly assigned to one of the following two groups: (1) NDT or (2) AST/NDT. The participants were assessed using the GMFM, Pediatric Balance Scale (PBS), Timed Up and Go (TUG) test, and spatiotemporal gait parameters.	The GMFM, PBS, and TUG test for both groups showed a statistically significant increase (p < 0.05). Three children were excluded. Compared to the NDT group (n = 9), the AST/NDT group (n = 8) demonstrated a significant increase in spatiotemporal gait parameters (p < 0.05).
3. MARILYN COHEN-HOLZERA ET AL,2011	The effect of combining daily restraint with bimanual intensive therapy in children with hemiparetic cerebral palsy: A self-control study	Included were nine children (ages 6-9 yr), with Manual Ability Classification System scores of 2-3, Gross Motor Functional Classification System 1-2; Intervention: 10 days, six hours per day including one hour of restraint followed by five hours of bimanual activities	No significant change was observed during the pre-intervention control period in any of the outcome measures; a significant improvement in all outcome parameters was noted after the intervention as compared to the control period. These achievements were still significantly higher than baseline values at six months post-intervention
4.	Hand-arm bimanual intensive therapy and daily functioning of	Forty-one children with bilateral CP, aged 4 to 16 years, classified in levels I to III of the Manual Ability	Children participating in HABIT showed greater improvements in daily functioning

PRISCILLA R P FIGUEIREDO ET AL,2020	children with bilateral cerebral palsy: a randomized controlled trial	Classification System, were randomly assigned to HABIT (90h) (n=21) or to customary care (4.5h) (n=20). Participants' daily functioning (Pediatric Evaluation of Disability Inventory [PEDI], Canadian Occupational Performance Measure [COPM]), unimanual dexterity (Jebsen-Taylor Test of Hand Function, Box and Blocks Test [BBT]), and bimanual performance (Both Hands Assessment) were assessed pre-, post-, and 6 months after the intervention. Linear mixed-effects models were used for inferential analysis.	(COPMperformance,p<0.01; COPMsatisfaction, p<0.05, PEDIfunctional skills, p<0.01, PEDicaregiver assistance, p<0.05)
5.  Meshi Kindergarten et al. 2014	Efficacy of Constraint-Induced Movement Therapy and Bimanual Training in Children with Hemiplegic Cerebral Palsy in an Educational Setting	Twelve children (1.5–7 years) with congenital hemiplegic cerebral palsy were randomized to receive modified CIMT (n = 6) or HABIT (n = 6). Occupational and physical therapists administered usual and customary care for 8 weeks; children then crossed over to receive CIMT or HABIT 2 hr/day, 6 days/week for 8 weeks from their occupational therapist. The Assisting Hand Assessment and Quality of Upper Extremity Skills Test were administered 2 months prior to the intervention, immediately before, immediately after intervention, and 6 months after the first baseline assessment	Both groups demonstrated no change during baseline and comparable improvement following CIMT and HABIT (p < .001), which was maintained at 6-month follow-up. The result suggest that modified CIMT and HABIT provided in school-based settings can lead to improvements in quality of bimanual skill and movement patterns
6.  Andrew M. Gordon et al. 2011	Bimanual Training and ConstraintInduced Movement Therapy in Children With Hemiplegic Cerebral Palsy: A Randomized Trial	A total of 42 participants with hemiplegic CP between the ages of 3.5 and 10 years were randomized to receive 90 hours of CIMT or an equivalent dosage of functional bimanual training (HABIT) conducted in day-camp environments. The primary outcomes were changes in Jebsen-Taylor Test	Both the CIMT and HABIT groups demonstrated comparable improvement from the pretest to immediate posttest in the JTTHF and AHA (P < .0001), which were maintained at 6 months. GAS, however, revealed greater progress toward

		of Hand Function (JTTHF) and Assisting Hand Assessment (AHA) scores. Secondary measures included the Goal Attainment Scale (GAS).	goals for the HABIT group ( $P < .0001$ ), with continued improvement across test sessions for both groups ( $P < .0001$ ).
7. GONUL ACAR et al.2016	Efficacy of neurodevelopmental treatment combined with the Nintendo® Wii in patients with cerebral palsy	Thirty hemiparetic cerebral palsy patients (16 females, 14 males; mean age, 6–15 years) were included in the study and divided into two groups: a neurodevelopmental treatment+Nintendo Wii group (group 1, n=15) and a neurodevelopmental treatment group (group 2, n=15). Both groups received treatment in 45-minute sessions 2 days/week for six weeks. Use of the upper extremities, speed, disability and functional independence were evaluated using the Quality of Upper Extremity Skills Test, Jebsen Taylor Hand Function Test, ABILHAND-Kids test, and Pediatric Functional Independence Measure (self-care) before and after treatment.	There were statistically significant improvements in all parameters for group 1 and group 2 (except quality of function) after six weeks of treatment. Intergroup analysis showed that group 1 was superior to group 2 in mean change differences in the Jebsen Taylor Hand Function Test
8. Marina B. Brandao et al.2017	Does Dosage Matter? A Pilot Study of Hand-Arm Bimanual Intensive Training (HABIT) Dose and Dosing Schedule in Children with Unilateral Cerebral Palsy	Eighteen children with unilateral cerebral palsy were randomized to receive 6 hours of daily training over 3 weeks, totaling 90 hours (Group 90, n = 9) or receive 6 hours of daily training over 1.5 weeks, totaling 45 hours (Group 2 × 45, n = 9). After 6 months, Group 2 × 45 received an additional 45 hours. Hand (Jebsen–Taylor Test of Hand Function, Assisting Hand Assessment) and daily functioning tests (Canadian Occupational Performance Measure, Pediatric Evaluation of Disability Inventory) were administered before, immediately after, and 6	Both groups demonstrated significant improvements in hand and daily functioning after 90 hours (Group 90) or the first 45 hours (Group 2 × 45), without differences between groups. However, more children from Group 90 obtained smallest detectable differences in the Assisting Hand Assessment

		months after interventions	
9. Gonul acar et al.2021	the effect of the structured Neurodevelopmental Therapy Method-Bobath (NDT-B) approach on the feeding and swallowing activity of patients with cerebral palsy (CP) and feeding difficulties	Eighteen children with unilateral cerebral palsy were randomized to receive 6 hours of daily training over 3 weeks, totaling 90 hours (Group 90, n = 9) or receive 6 hours of daily training over 1.5 weeks, totaling 45 hours (Group 2 × 45, n = 9). After 6 months, Group 2 × 45 received an additional 45 hours. Hand (Jebsen-Taylor Test of Hand Function, Assisting Hand Assessment) and daily functioning tests (Canadian Occupational Performance Measure, Pediatric Evaluation of Disability Inventory) were administered before, immediately after, and 6 months after interventions	there was an improvement in the groups according to the subcategories of SOMA, the (oral motor intervention strategies), (nutrition-related caregiver training ) OMIS+NRCT+NDT-B group was superior in the trainer cup and puree subcategories of SOMA (P=0.05). significant correlation was observed between trunk control and oral motor functions in children with CP
10. Eun-Young Park et al.2017	Effect of neurodevelopmental treatment-based physical therapy on the change of muscle strength, spasticity and gross motor function in children with spastic cerebral palsy	One-hundred-seventy-five children with spastic cerebral palsy (88 diplegia; 78 quadriplegia) received neurodevelopmental treatment-based physical therapy for 35 minutes per day, 2-3 times per week for 1 year. Spasticity, muscle strength, and gross motor function were measured before and after treatment with the Modified Ashworth Scale, Manual Muscle Testing, and Gross Motor Function Measure, respectively.	Spasticity was significantly reduced after 1 year of treatment. The Gross Motor Functional Classification System levels I-II group showed a significant increase in muscle strength compared with the Gross Motor Functional Classification System levels III-V, and the latter showed a significant decrease in spasticity compared with the former
11. AJAYA.K SHAH ET AL.2019	To examine the effects of task-oriented activities based on neurodevelopmental therapy (TOA-NDT) principles on trunk control, balance, and gross motor function in children with spastic diplegic cerebral palsy		The mean difference of GMFM-88, PAS, PBS, and TIS was 8.53 (5.84-11.23), 0.90 (5.84-11.23), 4.86 (2.93-6.79), and 1.45 (0.30-2.60), respectively. TOA-NDT group showed improvement in all the outcomes.

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12 SWATI M. SURKAR ET AL. 2018	Hand-Arm Bimanual Intensive Therapy Improves Prefrontal Cortex Activation in Children With Hemiplegic Cerebral Palsy	Nine children with HCP and 15 children who were developing typically participated in the study. Children with HCP received 50 hours of HABIT. We assessed pre- and post-HABIT PFC activation using functional near-infrared spectroscopy neuroimaging. Bimanual coordination and motor task performance were assessed using the Assisting Hand Assessment (AHA), the average number of shapes matched, the shape matching errors, the reaction time, the 9-hole peg test, and the box and blocks test	The PFC activation decreased following HABIT and became similar to what was seen in the children who were developing typically. Post-HABIT PFC activation improvements paralleled with the improvements seen in the AHA and the behavioral outcomes. : HABIT potentially improves the PFC's involvement in the action planning of the upper extremity movements in children with HCP
13. RODRIGO ARANEDA ET AL.2020	Protocol of changes induced by early Hand-Arm Bimanual Intensive Therapy Including Lower Extremities (e-HABIT-ILE) in pre-school children with bilateral cerebral palsy: a multisite randomized controlled trial	study will include 50 pre-school children with CP from 12 to 60 months of age, comparing the effect of 50 h (2 weeks) of HABIT-ILE versus regular motor activity and/or customary rehabilitation. Assessments will be performed at 3 period times: baseline, two weeks later and 3 months later. The primary outcome will be the Gross Motor Function Measure 66. Secondary outcomes will include Both Hands Assessment, Melbourne Assessment-2, Semmes-Weinstein Monofilament Test, algometry assessments, executive function tests, ACTIVLIM-CP questionnaire, Pediatric Evaluation of Disability Inventory (computer adaptative test), Young Children's Participation and Environment Measure, Measure of the Process of Care, Canadian Occupational Performance Measure, neuroimaging and kinematics	The results of this study should highlight the impact of a motor, intensive, goal-directed therapy (HABIT-ILE) in pre-school children at a functional, neuroplastic and biomechanical level Effectiveness of e-HABIT-ILE, possibly changing the vision of these children's care and, moreover, decreasing the economic load on the health system regarding this population.
	The aim of this	GMFM is an instrument that	The results after the

<p>14</p> <p>GUSTAVO DESOUZART ET AL.2017</p>	<p>study was to verify the influence of the physiotherapy intervention according to the neuro developmental techniques according to the bobath concept, in the improvement of global motor skills in a 36-month-old child with bilateral spastic cerebral palsy</p>	<p>assesses gross motor function, important for the child's functional performance, and is primarily intended for children with CP. Studies indicate that it allows to better target the objectives of the intervention as well as to determine the most appropriate techniques</p>	<p>intervention, in which the same measurement and evaluation instruments were used, according to GMFM, showed a slight evolution, with child's gross motor capacities at the 18-month level there is improvement in all components of the ICF, which is more marked in activities. After analyzing this case the results obtained were positive although they were not reached in their fullness.</p>
<p>15.</p> <p>THOMAS BESIOS ET AL.2018</p>	<p>Effects of the Neurodevelopmental Treatment (NDT) on the Mobility of Children with Cerebral Palsy</p>	<p>Twenty children with cerebral palsy (7 with quadriplegia, 6 with diplegia and 7 with right hemiplegia). The children participated in an intervention that consisted of an 8-week Bobath program. GMFM-88, PEDI and TUG scores were measured across three time points during the intervention (a baseline measurement, a second at the end of the intervention and a post-intervention measurement one month after the end of the intervention).</p>	<p>the results of the NDT intervention showed that the participant children significantly improved their GMFM-88 and TUG scores between initial and final measurement and maintained this one month later (<math>F_{2,36} = 69,778</math>, <math>p &lt; 0.001</math>), while in PEDI the intervention program had no statistically significant effect (<math>F_{2,36} = 0.844</math>, <math>p = 0.438</math>).</p>
<p>16.</p> <p>VITALLI KASHUBAL ET AL.</p>	<p>BOBATH THERAPY FOR PHYSICAL REHABILITATION OF CHILDREN WITH CEREBRAL PALSY</p>	<p>theoretical analysis and generalization of special scientific and methodological literature; pedagogical observation, interview, and experiment (ascertaining and formative); motor abilities testing (with the Motor abilities assessment chart by Karel and Berta Bobath); clinical study (neurological examination to determine the severity of motor impairment according to the Gross Motor Function Classification System (GMFCS)); statistical data analysis. The ascertaining experiment involved 36 4-year-</p>	<p>Assessment of motor function showed that the development of motor function was improved in the following basic starting positions: by 5.42% in supine lying, by 3.94% in prone lying, by 5.16% in sitting erect, by 9.06% in kneeling, by 4.06% in squatting, and by 7.41% in standing. Development of motor skills was improved by 6.01% for rolling to the side and by 3.21% for rolling to the prone position Statistical analysis of the</p>

		old children with spastic diplegia cerebral palsy	motor impairment assessment data after the completion of the physical rehabilitation program revealed an increase in the number of children with GMFCS level I (the mildest form), which was statistically significantly higher (p
17. SINA LABAF ET AL. 2015	Effects of Neurodevelopmental Therapy on Gross Motor Function in Children with Cerebral Palsy	In a quasi-experimental design, 28 children with cerebral palsy were randomly divided into two groups. Neurodevelopmental therapy was given to a first group (n=15) with a mean age of 4.9 years; and a second group with a mean age 4.4 years (n=13) who were the control group. All children were evaluated with the Gross Motor Function Measure. Treatments were scheduled for three - one-hour sessions per week for 3 months.	We obtained statistically significant differences in the values between the baseline and post treatment in two groups. The groups were significantly different in laying and rolling (P=0.000), sitting (0.002), crawling and kneeling (0.004), and standing abilities (P=0.005). However, there were no significant differences in walking, running, and jumping abilities between the two groups (0.090).
18. Manal Abd El Wahab et al.2014	Effect of hand-arm bimanual intensive therapy on fine-motor performance in children with hemiplegic cerebral palsy	Thirty hemiparetic children ranged in age from 3 to 7 years with mild to moderate hand involvement participated in this study and they were divided equally into two groups (control and study). Children in the study group were engaged in play and functional activities that provided structured bimanual practice 3 h per day for 12 weeks, while children in the control group received traditional physical therapy program directed toward improving upper extremity use. Each child in the two groups was evaluated before and after the suggested treatment duration for detecting the level of hand performance using the Peabody Developmental Test of	Children in both groups demonstrated improved scores on the Hand grip strength while only children in the study group showed significant improvement in fine-motor performance scores (p < 0.05). The results suggest that, hand-arm bimanual intensive therapy appears to have a positive impact on hand function in children with hemiparetic cerebral palsy

		Motor Proficiency and hand grip strength by a hand held dynamometer.	
19. Marilyn cohen hozler et al 2016	The Effect of Bimanual Training with or Without Constraint on Hand Functions in Children with Unilateral Cerebral Palsy: A Non-Randomized Clinical Trial	Seventeen children aged 6–11 years with UCP participated in one of two intensive therapeutic camps: bimanual (n = 9) incorporating one hour of constraint (“Hybrid”) or Bimanual (n = 8). Each camp met for 2 weeks, 5 days per week for 6 hours each day. The Assisting Hand Assessment (AHA) and the Jebsen Taylor Test of Hand Function (JTTHF) examined bimanual and unimanual functions pre, post- and 3- months post-intervention	A significant improvement was noted in AHA scores for both groups between the pre-, post- and three months post-intervention [Hybrid (F2; 16 = 85.5, p < 0.01); Bimanual (F2; 16 = 15.4, p < 0.01)] with no significant differences between groups over time (F2; 30 = 0.74, p = 0.48). For the JTTHF, a significant improvement was noted in the affected hand following the Hybrid program (F2; 30 = 7.45, p = 0.01), while following the Bimanual program a significant difference was noted only in the less-affected hand (F2; 16 = 6.02, p < 0.01). Conclusion: Both interventions Hybrid and Bimanual were similarly effective for improving use of the affected hand in bimanual tasks
20. CHANDAN ET AL.2017	Effect of Manipulating Object Shape, Size and Weight Combined with HandArm Bimanual Intensive Training (HABIT) in Improving Upper Extremity Function in Children with Hemiplegic Cerebral Palsy-A Randomized Controlled Trial	Thirty patients who fulfilled the inclusion criteria were randomly allocated into two groups. Group A-HABIT with Object Manipulation, Group B-HABIT without Object Manipulation with 15 patients in each group. All the patients were evaluated with Pediatric Motor Activity Log, Modified Ashworth Scale and Manual Ability Classification System at pre-and post-treatment level.	There were significant decrease in spasticity MAS (p=0.001) & improvement in upper extremity function PMAL-R (p=0.001) & MACS (p=0.001) in both the groups post intervention. HABIT with object manipulation with different shape & size group had significant improvement on PMAL-R (p=0.002) & MACS (p=0.009) but no change in spasticity MAS (p=0.679) as compared to HABIT with object manipulation with similar shape & size group.
21. MARCIA ET	Neurodevelopmental Treatment (Bobath)	Through a comprehensive literature search it considered	No difference between neurodevelopmental

AL.2019	for Children With Cerebral Palsy: A Systematic Review	all randomized clinical trials that compared neurodevelopmental treatment with conventional physical therapy for children with cerebral palsy. used the Cochrane Risk of Bias Table to assess the risk of bias of the included randomized clinical trial, and the GRADE approach to evaluate the certainty of the body of the evidence.	treatment and conventional physical therapy was found for gross motor function (mean difference 1.40; 95% confidence interval -5.47 to 8.27, low certainty evidence).
22. KATHLRRM M. FRIEL ET AL.2016	Skilled Bimanual Training Drives Motor Cortex Plasticity in Children With Unilateral Cerebral Palsy	Twenty children with USCP (12 males) received therapy in a day camp setting, 6 h/day, 5 days/week, for 3 weeks. In structured skill training (n = 10), children performed progressively more difficult movements and practiced functional goals. In unstructured practice (n = 10), children engaged in bimanual activities but did not practice skillful movements or functional goals. We used the Assisting Hand Assessment (AHA), Jebsen-Taylor Test of Hand Function (JTTHF), and Canadian Occupational Performance Measure (COPM) to measure hand function. used single-pulse transcranial magnetic stimulation to map the representation of first dorsal interosseous and flexor carpi radialis muscles bilaterally.	Both groups showed significant improvements in bimanual hand use (AHA; $P < .05$ ) and hand dexterity (JTTHF; $P < .001$ ). However, only the structured skill group showed increases in the size of the affected hand motor map and amplitudes of motor evoked potentials ( $P < .01$ ). Most children who showed the most functional improvements (COPM) had the largest changes in map size
23. CLAUDIO L FERRE AT AL.2014	Feasibility of caregiver-directed home-based hand-arm bimanual intensive training: A brief report	Eleven children (aged 29–54 months) received 90 hours of home hand-arm bimanual intensive therapy (H-HABIT) provided by their trained caregivers. Parenting stress levels and compliance were monitored using the Parenting Stress Index and daily logs. Quality of bimanual performance and changes in	Ten children completed the study with caregivers completing on average 85.6 hours of H-HABIT. Daily logs indicated high caregiver compliance. Stress levels remained stable across the intervention. Children demonstrated significant improvements in the AHA

		performance/ satisfaction of functional goals were assessed using the Assisting Hand Assessment (AHA) and Canadian Occupational Performance Measure (COPM), respectively, at two pre treatment baseline sessions and two post treatment sessions (immediate and six months)	and COPM.
24. EREN AVCIL ET AT AL.2020	Upper extremity rehabilitation using video games in cerebral palsy: a randomized clinical trial	The 30 patients included in the present study RANDOMIZED IN TWO GROUPS: 1.VGBT group (VGBT using Nintendo Wii and LMC games) 2.control group (NDT-based upper extremity rehabilitation). Both groups trained 3 days a week for 8 weeks. Manual dexterity was evaluated using the “Minnesota Manual Dexterity Test (MMDT)”, functional ability using the “Childhood Health Assessment Questionnaire (CHAQ)” and the “Duruoz Hand Index (DEI)” and grip and pinch strengths using a dynamometer.	VGBT group was statistically superior to group II with respect to changes in MMDT (p<0.005) VGBT using Nintendo Wii and LMC games had slightly superior effects on manual dexterity in patients with CP while compared with NDT-based upper extremity rehabilitation. Furthermore, the effects of both treatment programs on grip strengths and functional ability were similar beneficial.
25. C. GRAZZIOTTIN DOS SANTOS AT AL.2014	Humeral external rotation handling by using the Bobath concept approach affects trunk extensor muscles electromyography in children with cerebral palsy	A crossover trial involving 40 spastic diplegic children was conducted. Electromyography (EMG) was used to measure muscular activity at sitting position (SP), during shoulder internal rotation (IR) and shoulder external rotation (ER) handlings, which were performed using the elbow joint as key point of control. Muscle recordings were performed at the fourth cervical (C4) and at the tenth thoracic (T10) vertebral levels. The Gross Motor Function Classification System (GMFCS) was used to assess whether muscle activity would vary according to different levels of severity	increase of EMG signal was observed during ER handling in both evaluated levels, suggesting an increase of muscle activation. These results indicate that humeral ER handling can be used for diplegic CP children rehabilitation to facilitate cervical and trunk extensor muscles activity in a GMFCS level-dependent manner

26. YA CHING HUNG ET AL.2020	Intensive upper extremity training improved whole body movement control for children with unilateral spastic cerebral palsy	Sixteen children with congenital hemiplegia (age 6– 12 years; GMFCS: I-II, MACS: I-II) were randomly assigned to either CIMT or HABILIT for 6 h per day training for 15 days. Children were asked to perform two whole body tasks (walking with and without a tray carrying) while 3-D kinematic analysis was performed before and after training.	After training, the HABILIT group increased the symmetry in height of their hands during tray carrying (more leveled tray). Both CIMT and HABILIT groups decreased the lateral motion of the tray. The CIMT group increased speed and stride length after training in both the walking and tray carrying tasks. Both groups also increased their minimum toe clearance (all $p < 0.05$ )
27. JAIN AT AL.2021	Effectiveness of modified constraint- induced movement therapy compared to hand arm bimanual intensive therapy on quality of upper extremity function in hemiplegic cerebral palsy children- an experimental study.	The study included 20 children who were diagnosed cases of hemiplegic CP. The experimental groups were given mCIMT and HABILIT with conventional therapy and the control group received only conventional therapy. Quality of upper extremity skills test (QUEST) was used as an outcome measure. All groups were evaluated with the QUEST before and after 4 weeks of treatment.	The results showed statistical difference in the final QUEST scores( $p=0.001$ ) between all the groups as well as difference in dissociated movement, grasp & weight bearing. There was however no difference in protective extension ( $p=0.704$ ) domain. Also, there was statistically no significant improvement in weight bearing and protective extension within the group while dissociated movement, grasp and QUEST Score showed improvement.
28. AJAYA K. SAH AT AL.2019	Effects of Task- oriented Activities Based on Neurodevelopmental Therapy Principles on Trunk Control, Balance, and Gross Motor Function in Children with Spastic Diplegic Cerebral Palsy: A Single-blinded Randomized Clinical Trial	Forty-four children with SDCP, aged 7–15 years, were recruited to participate in the randomized clinical trial. After random allocation, twenty-two ( $n = 22$ ) children with SDCP participated in TOA-NDT principles and twenty-two ( $n =$ 22) in conventional physiotherapy (CPT) program. Each group underwent the treatment for a duration of 60min per day, 6 days a week for 6 weeks. Gross motor function measure-88 (GMFM- 88), postural assessment scale	The mean difference of GMFM-88, PAS, PBS, and TIS was 8.53 (5.84–11.23), 0.90 (5.84–11.23), 4.86 (2.93–6.79), and 1.45 (0.30–2.60), respectively. TOA-NDT group showed improvement in all the outcomes. TOA-NDT principles are more beneficial in improving the trunk control, balance, and gross motor function parameters than CPT.

		(PAS), pediatric balance scale (PBS), and trunk impairment scale (TIS) were the outcome measures used to document the pre- and post-intervention effect.	
29. Ya ching hung et al.2017	<i>Improvements in Kinematic Performance After Home-Based Bimanual Intensive Training for Children with Unilateral Cerebral Palsy</i>	Seven children with USCP (aged 29–54 months, MACS level: I-III) received 90 hours (2 hrs/day, 5days/week for 9 weeks) of Home Hand-Arm Bimanual Intensive Training (H-HABIT) provided by trained caregivers. A bimanual drawer-opening task was evaluated with eight infrared cameras using VICON workstation4.6 before and after training to assess improvements in bimanual coordination.	H-HABIT training significantly decreased the time between one hand opening the drawer and the other hand manipulating its contents ( $p < 0.05$ ) and increased the percentage of time when both hands were moving simultaneously ( $p = 0.001$ ), which are indicators of improved temporal bimanual coordination. In addition, participants demonstrated a 26% decrease in trunk displacement ( $p < 0.05$ ), a 30% increase in upper arm joint excursion ( $p < 0.01$ ), and a 25% increase in elbow extension ( $p < 0.05$ ) for the affected side. All the improvements were maintained at 6-month posttest.
30. HAJAR SABOUR ET AL 2013	COMPARISON OF COMBINATION OF CIMT AND BIMANUAL INTENSIVE TRAINING WITH CIMT ALONE ON FINR MOTOR SKILLS OF CHILDREM WITH HEMIPLEGIC CEREBRAL PALSY	24 CHILDREN WITH HEMIPLEGIC CP AGED BETWEEN 60 AND 120 MONTHS , PARTICIPATED IN THIS STUDY. They were randomly assigned into CIMT and BIM training (n=12),CIMT alone (n=12) groups. The children in the CIMT and BIM group were received a combination of CIMT and bi-manual training. Each session was started with restraint on non-involved upper extremity and practicing with the involved upper extremity for three hours. This was followed with bi-manual training for another	Fine motor skills and upper limb function of these children in CIMT and HABIT and CIMT alone groups had significantly improved ( $P>0.05$ ).

		<p>three hours. Fine motor skills, upper limb function and muscle tone were assessed using Bruininks-Oseretsky Test of Motor Proficiency, Jebsen-Taylor Test of Hand Function and Modified Ashworth.</p>	
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## Discussion

The aim of this study was to see the impact of hand arm bimanual intensive therapy on the upper extremity on motor function and neurodevelopmental treatment impact on gross motor function . for this study we study a rct and systematic reviews and after analysing these studies i observed that there was effect of both therapy habit and ndt in the gross motor function in upper extremity. habit was mostly used for children with hemiplegic cp although, it's important to also note here that the association is a weak because out of the 30 studies, studies supported the improvement in the HABIT and NDT in upper extremity cerebral palsy children but at the same time 1 studies of NDT did not support the common notion, there is less study of NDT on upper extremity in spathic cerebral palsy, need more studies on NDT in cerebral palsy. This review found that the effects of neurodevelopmental treatment for children with cerebral palsy are still uncertain. further studies are required to assess the efficacy and safety of neurodevelopmental treatment for this purpose .

A highly intensive form of bimanual therapy, hand-arm bimanual intensive therapy (HABIT) incorporates motor learning principles of task selection, structured practice, grading of tasks, feedback and home practice[21] the HABIT group improved their bimanual coordination (decreased differences in heights of the two hands, better tray levelness) and decreased the lateral tray excursion after training. The HABIT group showed efficacy of training for UE movement control under dual-task conditions [22] HABIT in the form of 6 hours a day for three consecutive weeks (totaling 90 hours) led to the improvement of bimanual ability, unilateral dexterity, self-care function, and functional goals after the intervention and that the improvements were mostly maintained during the follow-up period[23]

- HABIT improved dexterity and performance of functional goals, but not bimanual performance, in children with USCP compared to a control group receiving intervention of equal intensity/duration that also controlled for increased caregiver attention. Home-based models provide a valuable, family-centered approach to achieve increased treatment intensity
- HABIT improved dexterity and performance of functional goals, but not bimanual performance, in children with USCP compared to a control group receiving intervention of equal intensity/duration that also controlled for increased caregiver attention. Home-based models provide a valuable, family-centered approach to achieve increased treatment intensity
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Home based-HABIT better handiness and performance of functional goals, but not bimanual performance, in children with unilateral spastic cerebral palsy compared to a control group receiving intervention of equal intensity/duration that also controlled for increased caregiver attention. Home-based models provide a valuable, family-centred approach to achieve increased treatment intensity. Some studies shows that mCIMT is more effective than HABIT

TOA-NDT principles are more beneficial in improving the trunk control, balance, and gross motor function parameters than CPT. Compared to other forms of HABIT, the standard 90-hour protocol for three successive weeks verified consistently small and significant outcome sizes for bimanual ability and unilateral dexterity. The result indicate that the standard form of HABIT is valuable to improve upper extremity function in children with CP. In count, we notice that some studies that were considered as HABIT with added training components adopted HABIT-ILE. HABIT-ILE is a was developed in recent years that was a new intervention. In all connected studies, there was insufficient in order on the allocation and proportion of upper extremity and lower extremity guidance time, which may perhaps interfere with the treatment intensity for bimanual ability and unilateral handiness (32, 33).

## **Conclusion**

HABIT is a child-friendly, intensive training planned for children with CP which focus on promote bimanual coordination. The result of this review suggest that HABIT in the form of 6 hours a day for three consecutive weeks (totalling 90 hours) lead to the enhancement of bimanual ability, unilateral dexterity, self-care function, and functional goals after the treatment and that the improvements were mostly maintained during the follow-up period. There is less randomised control trials for practice regarding neurodevelopmental treatment approaches for children with cerebral palsy. Future randomized clinical trials must be carefully planned and conducted to increase the quality of the evidence and reduce the doubt.

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