

The Effects of Early Constraint Induced Movement Therapy on the Functional Abilities of Children with Cerebral Palsy: A Systematic Review

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### Abstract

The purpose of this study was to examine the effects of physical therapy (PT) based interventions on the functional abilities of children with CP when implemented early (0-96 months). From the search, thirteen papers were retrieved and analyzed after the inclusion and exclusion criteria were applied. The primary intervention used in all of the papers was a variation of Constraint Induced Movement Therapy (CIMT) despite the broad search strategy used. Studies were assessed for their effects on quality and quantity of hand function and activities of daily living (ADLs)/function. Eight studies found significant results regarding the quality of hand use, six studies reported significant results of quantity of hand use, and two studies reported significance in regards to ADLs/function. In conclusion, children with CP can benefit from CIMT as part of their rehabilitation.

Keywords: *cerebral palsy, physical therapy, early intervention, child, constraint induced movement therapy, hemiplegia*

## **Introduction**

Cerebral palsy (CP) is the most common physical disability in children with an estimated prevalence of 1 in 500 (Sakzewski, Ziviani & Boyd, 2009). In the past, definitions of the disorder focused solely on the associated motor limitations. A more recent and inclusive definition of CP defines it as a “group of permanent disorders of the development of movement and posture causing activity limitations that are attributed to non-progressive disturbances that occur in the developing foetal or infant brain” (Rosenbaum, et al., 2007, p. 9). The motor disorders commonly seen with cerebral palsy are frequently paired with dysfunction of communication, cognition, perception, and behaviour due to secondary complications.

One of the most common types of CP is hemiparetic, or an incomplete paralysis of one side of the body (Deluca, Echols, Law, & Ramey, 2006). This presentation often involves impairments in sensation, sensorimotor processing, and motor coordination, and has implications on a child’s functional development and abilities (Deluca, et al., 2006). It is estimated that hemiplegia accounts for approximately 30-40% of all children who are born with CP (Watson, Stanley et al. 1999; Haan, Chan et al. 2004).

Although CP is a complex disorder involving several associated impairments, this systematic review has chosen to focus mainly on motor impairments requiring physical therapy intervention. Primary motor impairments include altered muscle tone, muscle coordination and impaired postural control (Barry, 1996). Secondary problems include those caused by altered biomechanics such as muscle and joint contractures, muscle weakness, decreased exercise tolerance and functional limitations in activities of daily living (ADLs) (Barry, 1996). There are many different variations and presentations of CP that may include any combination of the above mentioned impairments.

Children with CP typically require ongoing physical and occupational therapy to manage their disability (Craig, 1999). Common interventions implemented by physical therapists might include upper extremity therapy, strength training programs, cardiovascular fitness and aerobic programs, sensorimotor training programs, balance training, therapy with animals, and generalized PT therapies (Anttila, Autti-Rämo, Suoranta, Mäkelä, & Malmivaara, 2008).

Generalized PT treatments are broadly defined and may include neurodevelopmental training, manual therapy, PT modalities and caregiver education (Anttila et al., 2008; Barry, 1996).

Upper extremity training involves a wide variety of therapies including occupational therapy, casting, constraint-induced therapy and prehensile training (Anttila et al., 2008, Sakzewski et al., 2009). Although there has been limited evidence for occupational therapy and casting, research has shown improvements in function with constraint-induced therapy and prehensile training (Anttila, 2008; Sakzewski, 2009). Previous findings have shown a need for further research regarding the frequency, intensity, and timing of interventions (Martin, Baker & Harvey, 2010).

Early intervention is “a systematic delivery of services in infancy and early childhood” (Simeonsson, Cooper & Scheiner, 1982, p. 636). It is important to intervene at an early age, often before a definitive diagnosis, to optimize plasticity of the developing nervous system (Harbourne et al., 2010). Several different sources have shown that children who have or are at risk for developmental disability are positively affected by early intervention (Manjnemer, 1998). Furthermore, interventions for both the child and family improve different aspects of treatment including, but not limited to, outcome measure results, parent-child relationships, and the overall family environment (Majnemer, 1998).

A recent systematic review was performed of common PT interventions in school aged children with CP; however it was identified that their search criteria may have been too precise

and may have excluded some intervention strategies (Martin et al., 2010). The current review will aim to include a broader range of interventions that may be performed by a physical therapist. In an effort to include papers of higher level of evidence, this review will limit inclusion to RCTs and cohort studies. Furthermore, to encompass the primary stages of gross motor development, as well as those individuals who have delayed development due to CP, the included age group will be up to 96 months. The purpose of this review is to explore the effects of early physical therapy interventions on physical function of children with CP when implemented prior to nine years old.

## **Methods**

### **Data sources**

A systematic search strategy was employed in order to collect relevant studies conducted in the last 16 years. The electronic databases Medline (OvidSP), Embase (Ovid SP), PubMed (PubMed), CINAHL (Ebsco), and Cochrane (OvidSP) were searched for RCTs published between 1995 and April 2012 in English. Variations of the terms *cerebral palsy*, *physical therapy*, *early intervention*, *time*, *child* and *infant* were used as keywords and subject headings and combined through a structured search method to retrieve relevant articles (see Appendix 1). To ensure completeness of the search strategy, snowballing and hand searching were utilized both manually and through online search engines.

### **Selection of studies**

The titles and abstracts of the papers found after the initial search was performed were reviewed independently by two authors to determine whether the studies were eligible for inclusion in the systematic review (see Table 1 for details of inclusion and exclusion criteria). For any discrepancies, the article was kept and a third author assisted in determining suitability.

The three remaining authors independently reviewed the remaining full articles and eliminated any that did not meet the eligibility criteria.

Table 1

*Inclusion and Exclusion Criteria of Selected Studies*

<b>Inclusion Criteria</b>	<b>Exclusion Criteria</b>
<ul style="list-style-type: none"> <li>• Randomized control trials and cohort studies</li> <li>• Published in English</li> <li>• Full text between 1995 and April 2012</li> <li>• Children with a diagnosis of CP 96 months of age or younger</li> <li>• Children with Spastic Hemiplegia</li> <li>• Interventions within the scope of practice of PT</li> </ul>	<ul style="list-style-type: none"> <li>• Medical or pharmacological interventions are primary treatment</li> <li>• Children with CP over the age of 96 months</li> <li>• Children with other neurological disorders</li> <li>• Children with other types of CP</li> <li>• Published before 1995</li> </ul>

### **Data extraction**

A data extraction form was generated to organize study and participant characteristics, and to collect information pertinent to answering the study question. Information extracted included: study design, presence of blinding and randomization, sample size, number of participants in treatment and control groups, mean age, CP classification, treatment type, control type/comparison group, duration of intervention, duration of follow-up, number of drop outs, outcome measure of interest, and results. The data was extracted independently by three authors, and then compared to ensure accuracy.

### **Assessment of study quality**

The quality of the reported studies was assessed using the PEDro scale. The PEDro Scale involves assessment of eleven different items that reduce the chance of bias in a randomized control trial. Such items include random allocation, concealment of allocation, similarity of groups at baseline, blinding of participants and more (Tooth et al., 2005). All items except for the first are evaluated and scored on a 0-10 point scale. Criterion 1, referring to eligibility criteria, is left out as it is a measure of external validity, not internal (Maher et al., 2003). Sackett's Levels of Evidence was used to summarize the quality and strength of evidence of the included studies. According to Sackett's levels, 1A refers to a systematic review of RCTs, Level 1B a large RCT and Level 2 a cohort studies with strength of evidence decreasing to level 5, an expert opinion (Sackett, Strauss, Richardson, Rosenberg, & Haynes, 2000). Two group members independently reviewed each paper using the PEDro scale and Sackett's Levels of Evidence, compared grading, and discussed any disagreements that surfaced.

### **Data synthesis**

Due to the variance in designs, interventions and outcome measures in each study, qualitative methods of data synthesis were chosen. To summarize findings, outcome measures were classified by the research team as pertaining to Quality or Quantity of Hand Use, or ADLs and Function (see Table 2). P-values were extracted from each study to confirm significance. The results of each article were simplified to state whether there was a significant improvement or not.

Table 2

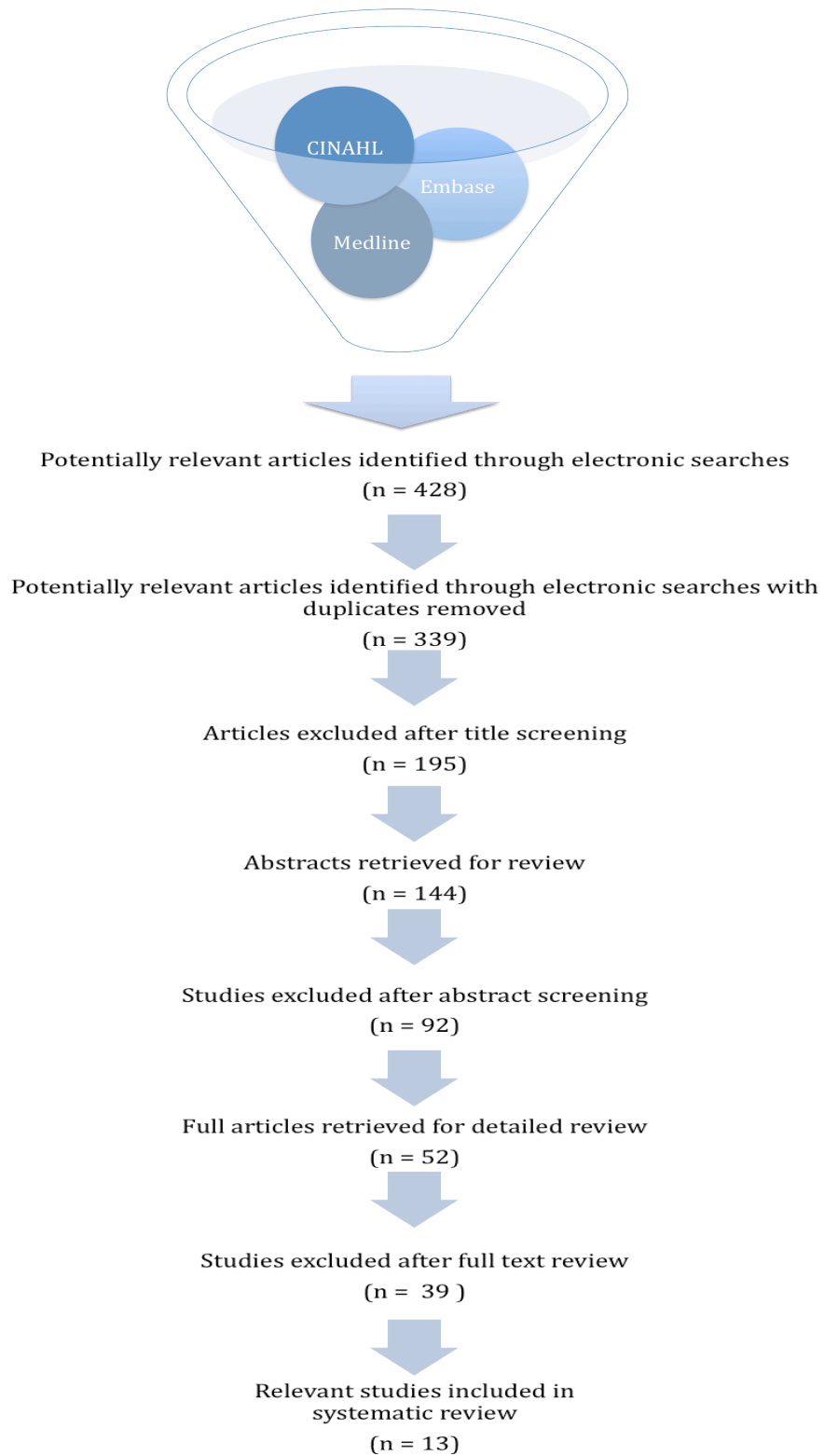
*Functional Classification of Outcome Measures*

<b>Functional Classification</b>	<b>Outcome Measures</b>
Quality of Hand Use	Melbourne Assessment of Unilateral Upper Limb Function (MAUULF); Assisted Hand Assessment (AHA); Quality of Upper Extremity Skills Test (QUEST)- Grasp/release; QUEST- Dissociated movement; QUEST- Protective extension; QUEST- Weight bearing; QUEST- Global scale; Pediatric Motor Activity Log (PMAL)- How well; Jebsen-Taylor Test of Hand Function (JTTHF); Bruininks-Oseretsky Test of Motor Proficiency (BOTMP); Caregiver Functional Use Survey (CFUS)- How well; Dimensions of Mastery Questionnaire (DMQ); Besta Scale (Besta)- Grasp; Besta- Global; Box and Blocks Test (BBT)- Affected limb; Erhardt Developmental Prehension Assessment (EDPA)
Quantity of Hand Use	PMAL- How often; CFUS- How often; Besta- Bimanual spontaneous use; Pediatric Arm Function Test (PAFT)- Unilateral task of affected arm use; Toddler Arm Use Test (TAUT)
ADLs/ Functions	Pediatric Evaluation of Disability Inventory (PEDI)- Functional abilities; PEDI- Independence; Besta- 2-6 years; Besta- 7-8 years; Functional Independence Measure for Children (WeeFIM)- Motor; WeeFIM- Self-care; WeeFIM- Communication; WeeFIM- Cognition; WeeFIM- Total; PAFT- Functional ability



## Results

Figure 1. Flowchart of study selection



Following the electronic literature search, 428 articles were found. Once duplicates were removed, 339 articles remained. Of those articles, several were rejected as they did not meet the inclusion or exclusion criteria. Figure 1 illustrates the levels at which papers were screened and excluded. Additional papers found through hand searching and snowballing were either duplicates or were excluded based on inability to fulfill criteria. The final 13 studies consisted of 12 randomized control trials and 1 cohort study. The level of evidence ranged from I to II with 12 studies contributing Level IB evidence and one study contributing Level II evidence. PEDro scores ranged from 5-8 as seen in Table 3.

The two most common outcome measures used in the included studies were the Paediatric Motor Activity Log (PMAL) and the Assisted Hand Assessment (AHA). Of the 13 included studies, 6 of them utilized the PMAL and 5 used the AHA. Due to the nature of the material in the PMAL, both quality and quantity of hand movement were assessed whereas the AHA only assessed quality. Both assessments illustrate increased or decreased usage of the affected limb; however, PMAL results are parent-reported.

From the 13 studies that met the inclusion criteria only one intervention was investigated. Each of the included studies examined a variation of Constraint-Induced Movement Therapy (CIMT). Different types of CIMT were used, including modified (mCIMT), modified combined with bimanual task specific training (mCIMT-BiT), and ecological (eco-CIMT). While most were compared to a control group consisting of physical or occupational therapy treatment, 2 studies used a cross-over design and provided the control with delayed CIMT. Another study compared CIMT in the home versus clinic while 2 others compared to different types of treatment, bimanual intensive rehabilitation treatment (IRP) and standard treatment (ST).

Study results illustrated the significance of intervention on quality and quantity of hand and arm use and its effect on ADLs and function. Many different outcome measures were used to attain the results. The breakdown of each outcome measure and the results is illustrated in Table 3. Of the 13 studies found, 8 found significant results regarding the quality of hand use following intervention, 3 found mixed results and 2 found no significance. Eight studies reported results of quantity of hand use; of those 6 reported significant findings, 1 reported no significance and 1 did not report findings. Of the 4 studies that examined ADLs and function, 2 reported significance and 2 had mixed results.

Table 3

*Level of Evidence, Study Quality and Outcome Measure Results by Study*

<b>Study (Date/ Author)</b>	<b>Level of Evidence</b>	<b>Study Quality</b>	<b>Outcome Classification</b>	<b>Outcome Measures</b>	<b>Results</b>
Aarts, et al. (2010/2011)	1B	7	Quality	MAUULF AHA	NSD Sig
Al-Oraibi & Eliasson (2011)	2	5	Quality	AHA	Sig
Case-Smith, et al. (2012)	1B	7	Quality	AHA QUEST- Grasp/release QUEST- Dissociated movement PMAL-How well PMAL-How often	Sig Sig  Sig  Sig Sig
			Quantity		

Charles, et al. (2006)	1B	7	Quality	JTTHF	Sig
				BOTMP	Sig
				CFUS-How well	Not reported
			Quantity	CFUS-How often	Not reported
de Brito Brandão, et al. (2010)	1B	8	Quality	Adapted JTTHF	NSD
			Function	PEDI-Functional abilities	Sig
				PEDI-Independence	Sig
Eliasson, et al. (2011)	1B	7	Quality	AHA	Sig
				DMQ	NSD
Facchin, et al. (2011)	1B	7	Quality	Besta-Global	Sig for CIMT and IRP
				Besta-Grasp	Sig for CIMT and IRP
				QUEST-Global	Sig for CIMT and IRP
				QUEST-Grasp	Sig for CIMT; NSD for IRP
				QUEST-Dissociated movement	Sig for CIMT and IRP
				QUEST-Protective extension	Sig for CIMT; NSD for IRP
				QUEST-Weight	Sig for CIMT

				bearing	and IRP
			Quantity	Besta- Bimanual	Sig for CIMT
				spontaneous use	and IRP
			Function	Besta-2-6 years	Sig for CIMT
					and IRP
				Besta-7-8 years	NSD for CIMT
					and IRP
Hsin, et al. (2011)	1B	8	Quality	BOTMP	Sig
				PMAL-How well	Sig
			Quantity	PMAL-How often	Sig
Rostami & Malamiri (2012)	1B	7	Quality	BOTMP-Upper	Sig
				limb speed and	
				dexterity	
				BOTMP-Upper	Sig
				limb coordination	
				PMAL-How well	Sig
			Quantity	PMAL-How often	Sig
Sung, et al. (2005)	1B	6	Quality	BBT-Affected	Sig
				limb	
				EDPA	Sig
			Function	WeeFIM-Motor	Sig
				WeeFIM-Self-	Sig
				care	
				WeeFIM-	NSD
				Communication	
				WeeFIM-	NSD
				Cognition	
				WeeFIM-Total	NSD

Taub, et al. (2004)	1B	8	Quality	PMAL-How well	Sig
			Quantity	PMAL-How often	Sig
				TAUT	Sig
Taub, et al. (2011)	1B	5	Quality	PMAL-How well	Sig
			Quantity	PAFT-Unilateral task of affected arm use	Sig
			Function	PAFT-Functional ability	Sig
Wallen, et al. (2011)	1B	8	Quality	AHA	NSD
				Revised PMAL- How well	NSD
			Quantity	Revised PMAL- How often	NSD

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\* significance indicated by  $p < 0.05$  or as stated within results/discussion of each article

### Discussion

Despite the broad search strategy used to capture all interventions within the PT scope of practice, the primary intervention used in all of the papers selected was CIMT. CIMT, also referred to as constraint therapy (CT), constraint-induced therapy (CIT), or forced use therapy (FUT) is an intervention employed by physical and occupational therapists to improve the arm use of an individual with hemiplegia. Therapy involves physical restraint of the non-affected limb to encourage the patient to use the affected arm (Lam-Danji & Fehlings, 2006). The restraint may be worn for any period up to 24 hours per day. While wearing the restraint, the patient may engage in formal or structured practice sessions, or be encouraged to partake in

normal ADLs (Lam-Danji & Fehlings, 2006). CIMT has been used as a treatment for adults post-stroke and has been shown to improve motor control in the affected limb (Lam-Danji & Fehlings, 2006). Proposed benefits of this type of therapy include: improved quality of hand use, new motor movements of the affected arm or hand, more spontaneous use of the affected arm or hand, and improved fine motor function and grasp (Lam-Danji & Fehlings, 2006).

### **Outcome measures**

The most common outcome measures used in the included articles were the AHA and the PMAL. The AHA has been proven to be a valid measure of bimanual upper extremity task performance in children aged 18 months to 12 years with unilateral CP (Krumlinde-Sundholm, Holmefur, Kottorp, & Eliasson, 2007). The test has also been shown to have strong inter-rater, intra-rater, and test-retest reliability (Krumlinde-Sundholm et al., 2007). A study done by Huang, Fethers, Hale & McBride (2009) reported that the AHA is currently the only reliable and valid measure used in pediatric CIMT studies that measure the functional use of the affected limb in bimanual tasks. The PMAL is a parent reported measure of frequency and quality of affected upper extremity use. It has also been shown to have sound psychometric properties. Wallen, Bundy, Pont, and Zivaini (2008) reported strong construct validity and reliability for this test. While these measures demonstrate sound psychometric properties, the lack of consistency of outcome measures used in research of CP makes it difficult to compare results of one study to another.

### **CIMT interventions**

**Traditional CIMT.** Seven studies examined the effects of traditional CIMT on children with spastic hemiplegia. Al-Orabi & Eliasson (2011) compared CIMT to neurodevelopmental training (NDT). Though results showed an increase of AHA scores in both CIMT and NDT

groups, all seven children in the CIMT group showed improvement with five improving in more than 3 raw scores which reflects the smallest detectable difference. Case-Smith et al. (2012) compared two different dosage groups (3 hr/day and 6 hr/day) with the AHA, PMAL, and Quality of Upper Extremity Skills Test (QUEST) all used as outcomes of interest. In all assessments, significant gains were made in both dosage groups. At six month follow-up, a small amount of post-treatment gains were lost but losses at follow-up were not statistically significant. Hsin et al. (2011) found that both CIMT and traditional rehab groups had improvements on the Bruininks-Oseretsky Test of Motor Proficiency (BOTMP) but the CIMT group improved more at both post-treatment and follow-up. On the PMAL, the CIMT group improved more on the Amount of Hand Use subscale as well as the Quality of Hand Use subscale. Rostami & Malamiri (2012) conducted a study comparing an intervention of home CIMT to a control of CIMT treatment within a clinic. The home group achieved higher scores on the BOTMP which indicated greater improvements in upper limb function. Sung et al. (2005) found that after six weeks of treatment, the group that received forced-use therapy (FUT) in conjunction with conventional rehabilitation scored higher on the Box and Blocks Test (BBT) and the Erhardt Developmental Prehension Assessment (EDPA) than those in the control group. The self-care score on the Functional Independence Measure for Children (WeeFIM) measure had also significantly improved in the FUT group. In the 2004 study done by Taub et al., upper-extremity CIT that had been previously used with an adult stroke population was adapted for use with hemiparetic CP children. Results showed improved use in the affected extremity as well as gains on the PMAL in those that had received the intervention. A second study done by Taub et al. (2011) showed that children who received immediate CIMT treatment had a tendency to use their affected limb more often and with more dexterity than those who crossed over from the



control group. Also, the follow-up showed that children who received the immediate CIMT intervention continued to show larger gains in all measures in comparison to the cross-over group suggesting that earlier intervention may be more beneficial.

**Modified CIMT (mCIMT).** Five studies examined the effects of mCIMT on children with spastic hemiplegia. Aarts et al. (2010) found significantly greater improvements in spontaneous use of the affected arm in the intervention group than in the control group after six weeks of mCIMT followed by two weeks of mCIMT-BiT. AHA scores increased illustrating improved use of the affected limb in bimanual activities (Krumlinde-Sundholm, 2007). Case-Smith et al. (2012) demonstrated improved scores in both Jebsen-Taylor Test of Hand Function (JTTHF) and BOTMP scores regarding unilateral movement efficiency and motor performance. The study by de Brito Brandão et al (2010) compared mCIMT intervention to a control group receiving regular occupational therapy. Though results showed no significant differences between groups in regards to the JTTHF scores, significant differences in functional skills and independence were found. Facchin et al. (2011) compared mCIMT to both IRP and ST and found a significant improvement in QUEST scale results with respect to grasp function and weight bearing. When comparing mCIMT to ST alone, the QUEST scale showed the most significant improvements for dissociated movements in those participating in mCIMT. On the Besta scale, mCIMT was compared to IRP and was found to be more effective in improving grasp function than IRP. Lastly, Wallen et al. (2011) found that there was no statistically significant difference between the mCIMT or intensive occupational therapy group for improving upper limb function and completion of ADLs. The study conducted by Wallen et al was the only study that did not find significance in their results for either quality or quantity of hand movement although both groups showed improvement. This may be due to the intensive

nature of the control intervention suggesting that some of the benefits of CIMT may be due to the intensity of treatment.

**Ecological CIMT.** One study looked at the effects of ecological-CIMT on young children with unilateral CP (Eliasson et al., 2011). Ecological training is CIMT delivered in the child's usual environment conducted by their regular caregivers under the supervision of a therapist. The study was a randomized crossover design with a four month "washout" period. Results showed a significant effect of Eco-CIMT when compared to control, with improvements on the AHA. Therefore, young children with unilateral CP can benefit from Eco-CIMT.

### **Dose response**

Of the studies retrieved, one paper looked specifically at the dose-response relationship. Case-Smith et al. (2012) hypothesized that after 6 months, those children who received 6 hours of mCIMT versus 3 hours would have better maintained their improvements over the follow-up period. In their study, they found that both groups showed significant improvements in their AHA and PMAL scores; however, at follow-up, there was a non significant, similar decline in performance between the two dosage groups. Thus, the different dosage applied may not have an effect on performance at follow-up.

### **Setting: Clinic versus at home**

Rostami & Malamiri (2012) examined the effects of home CIMT versus CIMT treatment within a clinic on upper extremity function. As stated above, they reported improved scores on the BOTMP in the home group compared to the clinic group. They concluded that at home CIMT is a feasible and effective way of implementing CIMT. By providing treatment in the home, learning is facilitated as the child acquires new skills in a more appropriate, contextual setting.

## Functional Outcomes

**Quality of hand use.** All studies included in the present review used an outcome measures assessing quality of hand use as defined by the research team. Of the thirteen studies retrieved, seven reported significant changes in quality of hand use after some variation of CIMT training. Aarts et al. (2010) reported no significant differences in scores on the Melbourne Assessment of Unilateral Upper Limb Function (MAUULF). According to their paper, to be considered clinically significant, there needed to be a 12% change in scores of this outcome measure, which was not achieved in their studies. They reported that the MAUULF may not be as sensitive to change as other outcome measures. Furthermore, they hypothesized that a longer period of CIMT training may have allowed the children to reach a significant score on the MAUULF questionnaire. In 2010, de Brito Brandão and colleagues reported no difference in gains in manual dexterity as measured by the JTTHF. They reported that a potential reason for the difference of their findings to similar studies was that in their protocol, children engaged in CIMT for 3 hours per day, as opposed to 6 hours used in comparable studies (de Brito Brandão et al., 2010). They concluded that gains in dexterity may be dependent on the intensity of CIMT. Their findings contradict the results of the study by Case-Smith et al (2012) who found that those individuals who received 3 hours/day and 6 hours/day of treatment improved similarly. This suggests that the effect of treatment dosage is still unclear. While Eliasson et al. (2011) reported that Eco-CIMT improved hand use in children with hemiplegic CP, there was no significant relationship between hours of training, age, or mastery of behaviour. They attributed this lack of significance to the diversity of their population. Wallen et al. (2011) found no significant differences between treatment groups in quality of hand use as measured by the AHA and the PMAL- Quality of Hand Use subscale. As mentioned above, a possible explanation for their

findings may be that the control intervention, intensive occupational therapy, was rigorous enough to induce positive changes in the control group similar to the CIMT group.

**Quantity of hand use.** Eight studies used an outcome measure related to quantity of hand use. Of these eight studies, six reported significant results, one did not report their results, and one reported non-significant changes. Wallen et al. (2011) was the only author to report no significant change in the PMAL- Amount of Hand Use subscale. Potential reasons for their findings are outline in the above section.

**Activities of daily living.** Four papers used outcome measures related to ADLs and function. Of these studies, two reported significant improvements while the remaining two reported mixed results. Facchin et al. (2011) reported less significant improvements in ADL function for 7 and 8 year olds with a slight decline as measured by the Besta Scale. They state in their paper that these findings must be interpreted cautiously, as this result is contradictory to previous findings and requires long term follow-up. A possible reason provided for the worsening performance in 7 and 8 year olds is that at this age the children simply return to the incorrect movement patterns that they are accustomed to once their restraint is removed. Sung et al. (2005) reported significant improvements in scores on the WeeFIM for the motor and self care domains of the measure; however, there was no significant improvements in the communication or cognition domains of the WeeFIM, and consequently no significant improvements in the WeeFIM overall. Since the intervention used in this study was primarily targeting upper limb motor function, it follows that communication and cognitive domains of the WeeFIM would not be affected. As such, including these domains would affect the overall WeeFIM score, making it non-significant.

**Strengths and limitations**

Strengths of the present study are that the criteria included a wide range of ages and treatments. This allowed the authors to get a good idea of what research is available currently with regards to interventions for CP. Because of this broad inclusion, it was possible to gather information regarding dosage and setting of intervention although more research is certainly needed in these areas. Conversely, having a broad age range makes it difficult to draw strong conclusions about the importance of timing of these interventions.

A limitation of the present study is that it only found studies evaluating CIMT. This may be because only RCTs and cohort studies were included in an effort to maintain the quality of this review. Thus, it can be concluded that there is a lack of high quality research on other intervention strategies for individuals with CP. Finally, in an effort to remain true to the principles of physiotherapy, this review focused results on outcomes measures that reflected improvements in function and participation rather than simply looking at changes in body structure and function (Sykes, 2008).

A weakness of this study is that it only looks at spastic hemiplegic CP limiting its validity to only one subtype. Many of the other weaknesses of this review are reflective of common challenges in this field of research. CP by definition has a wide variation in the presentation of the condition. Even when individuals are categorized into different subtypes, the presentation still varies considerably from one individual to the next. Furthermore, because of this variation in CP, sample sizes of similar participants are often quite small and include broad age ranges. In the studies found, there was also limited reporting regarding the severity of the condition making it difficult to determine how severity of the condition affects response to treatments. Together these factors make it difficult for the researchers to make strong conclusions from their findings.

Finally, the lack of standardized control, often termed “usual care” or “standard PT treatment”, and outcome measures makes research in this field challenging when trying to compare on study to another.

### **Conclusion**

Children with CP can benefit from CIMIT as part of their rehabilitation. The results of the this review repeatedly showed improvements in functional movement with CIMIT over control treatments. In addition, the positive effects achieved from this intervention are significant after follow-up; however, further studies should investigate how long these improvements in upper limb function last. It is currently unclear as to whether intense OT protocols can have the same effect. It is also apparent that more studies are required to determine the optimal dosage and setting for this intervention.

### **Clinical relevance**

Clinically, CIMIT leads to significant improvements in quality and quantity of hand use with less significant improvements in ADLs and function also observed. These improvements were relatively consistent across different settings (clinic and home), and across different CIMIT protocols. CIMIT may be difficult to implement in a clinical setting, as the protocol requires up to 6 hours of intensive training per day delivered by a therapist to be effective. However, studies retrieved in this review indicate that Eco-CIMIT delivered by a child’s regular caregiver and at home CIMIT may be a more feasible and effective way of delivering this type of therapy.

### **Declaration of Interest**

The authors report no declarations of interest.

## References

- Aarts, P.B., Jongerius, P.H., Geerdink, Y.A., van Limbeek, J., & Geurts, A.C. (2010). Effectiveness of modified constraint-induced movement therapy in children with unilateral spastic cerebral palsy: A randomized controlled trial. *Neurorehabilitation and Neural Repair*, 24(6), 509-517. DOI: 10.1177/1545968309359767.
- Anttila, H., Autti-Rämo, I., Suoranta, J., Mäkelä, M., & Malmivaara, A (April 2008). Effectiveness of physical therapy interventions for children with cerebral palsy: a systematic review. *BMC Pediatrics*, 8(14). DOI: 10.1186/1471-2431-8-14.
- Barry, M. J. (1996). Physical therapy interventions for patients with movement disorders due to cerebral palsy. *Journal of Child Neurology*, 11(Supplement 1), S51-S60. DOI: 10.1177/088307389601100108.
- Case-Smith, J., DeLuca, S.C., Stevenson, R., & Ramey, S.L. (2012). Multicenter randomized controlled trial of pediatric constraint-induced movement therapy: 6-month follow-up. *American Journal of Occupational Therapy*, 66(1), 15-23. DOI: 10.5014/ajot2012.002386.
- Charles, J.R., Wolf, S.L., Schneider, J.A., & Gordon, A.M. (2006). Efficacy of a child-friendly form of constraint-induced movement therapy in hemiplegic cerebral palsy: a randomized controlled trial. *Developmental Medicine & Child Neurology*, 48, 635-642. DOI: 10.1017/S0012162206001356.
- Craig, M. (1999). Physiotherapy management of cerebral palsy: Current evidence and pilot analysis. *Physical Therapy Reviews*, 4, 215-228. DOI: 10.1179/108331999786821726.

de Brito Brandão, M., Mancini M.C., Vaz, D.V., de Melo, A.P., & Fonseca, S.T. (2010).

Adapted version of constraint-induced movement therapy promotes functioning in children with cerebral palsy: a randomized controlled trial. *Clinical Rehabilitation*, 24, 639-647. DOI: 10.1177/0269215510367974.

DeLuca, S.C., Echols, K., Law, C.R., & Ramey, S.L. (2006). Intensive pediatric constraint-induced therapy for children with cerebral palsy: randomized, controlled, crossover trial. *Journal of Child Neurology*, 21, 931-938. DOI: 10.1177/08830738060210110401.

Eliasson, A.C., Shaw, K., Berg, E., & Krumlinde-Sundholm, L. (2011). An ecological approach of constraint induced movement therapy for 2-3 year old children: A randomized control trial. *Research in Developmental Disabilities*, 32, 2820-2828. DOI:10.1016/j.ridd.2011.05.024.

Facchin, P., Rosa-Rizzotto, M., Pozza, L.V., Turconi, A.C., Pagliano, E., Sigorini, S., et al. (2011). Multisite trial comparing the efficacy of constraint-induced movement therapy with that of bimanual intensive training in children with hemiplegic cerebral palsy. *American Journal of Physical Medicine and Rehabilitation*, 90, 539-553. DOI: 10.1097/PHM.0b013e3182247076.

Haan, E., A. Chan, et al. (2004). The South Australian Cerebral Palsy Register - Annual Report 2003. Adelaide, The South Australian BirthDefects Register.

Harbourne, R., Willett, S., Kyvelidou, A., Deffreyes, J. & Stergiou, N. (2010). A comparison of interventions for children with cerebral palsy to improve sitting postural control: a clinical trial. *Physical Therapy*, 90(12), 1881-1898. DOI: 10.2522/ptj.2010132.



- Hosseini, S.M., Sourtiji, H., & Taghizadeh, A. (2010). Effect of child friendly constraint induced movement therapy on unimanual and bimanual function in hemiplegia. *Iranian Rehabilitation Journal*, 9(12), 50-54.
- Hsin, Y., Chen, F., Lin, K., Kang, L., Chen, C., & Chen, C. (2012). Efficacy of constraint-induced therapy on functional performance and health-related quality of life for children with cerebral palsy: A randomized controlled trial. *Journal of Child Neurology*, 00(0), 1-8. DOI: 10.1177/0883073811431011.
- Krumlinde-Sundholm, L., Holmefur, M., Kottorp, A., & Eliasson, A. (2007). The assisting hand assessment: current evidence of validity, reliability, and responsiveness to change. *Developmental Medicine and Child Neurology*, 49, 259-264. DOI: 10.1111/j.1469-8749.2007.00259.x
- Maher, C. G., Sherrington, C., Herbert, R. D., Moseley, A. M., & Elkins, M. (2003). Reliability of the PEDro scale for rating quality of randomized control trials. *Physical Therapy*, 83, 713-721.
- Majnemer, A. (1998). Benefits of early intervention for children with developmental disabilities. *Seminars in Pediatric Neurology*, 5(1), 62-69. DOI: 10.1016/S1071-9091(98)80020.
- Martin, L., Baker, R., & Harvey, A. (2010). A systematic review of common physiotherapy interventions in school-aged children with cerebral palsy. *Physical & Occupational Therapy in Pediatrics*, 30(4), 294-312. DOI:10.3109/01942638.2010.500581.
- Rosenbaum, P., Paneth, N., Leviton, A., Goldstein, M., Bax, M., Damiano, D., et al. (2007). A report: The definition and classification of cerebral palsy April 2006. *Developmental*

- Medicine & Child Neurology*, 49, (s109), 8-14. DOI: 10.1111/j.1469-8749.2007.tb12610.x.
- Rostami, H.R., & Malamiri, R.A. (2012). Effect of treatment environment on modified constraint-induced movement therapy results in children with spastic hemiplegic cerebral palsy: a randomized controlled trial. *Disability & Rehabilitation*, 34(1), 40-44. DOI: 10.3109/09638288.2011.585214.
- Sackett, D.L., Strauss, S.E., Richardson, W.S, Rosenberg, W., & Haynes, R.B (2000). Evidence-based medicine: How to practice and teach EBM. Philadelphia, Pa: Churchill-Livingstone.
- Sakzewski, L., Ziviani, J., & Boyd, R. (2009). Systematic review and meta-analysis of therapeutic management of upper-limb dysfunction in children with congenital hemiplegia. *Pediatrics*, 123, 1110-1123. DOI: 10.1542/peds.2008-3335.
- Simeonsson, R.J., Cooper D.H., & Scheiner A.P. (1982). A review and analysis of the effectiveness of early intervention programs. *Pediatrics*, 69, 635-641.
- Sung, I., Ryu, J., Pyun, S., Yoo, S., Song, W., & Park, M. (2005). Efficacy of forced-use therapy in hemiplegic cerebral palsy. *Archives in Physical Medicine and Rehabilitation*, 86, 2195-2198. doi:10.1016/j.apmr.2005.05.007.
- Sykes, C. (2008). The international classification of functioning, disability and health: Relevance and applicability to physiotherapy. *Advances in Physiotherapy* , 10, 110-118.

- Taub, E., Griffin, a., Uswatte, G., Gammons, K., Nick, J., & Law, C.R. (2011). Treatment of congenital hemiparesis with pediatric constraint-induced movement therapy, *Journal of Child Neurology*, 26(9), 1163-1173. DOI: 10.1177/0883073811408423.
- Taub, E., Ramey, S.L., DeLuca, S., & Echols, K. (2004). Efficacy of constraint-induced movement therapy for children with cerebral palsy with asymmetric motor impairment. *Pediatrics*, 113(2), 305-312. DOI: 10.1542/peds.113.2.305.
- Wallen, M., Bundy, A., Pont, K., & Ziviani, J. (2008). Psychometric properties of the pediatric motor activity log used for children with cerebral palsy. *Developmental Medicine and Child Neurology*, 51, 3, 200-208. DOI: 10.1111/j.1469-8749.2008.03157.x
- Wallen, M., Zivaini, J., Naylor, O., Evans, R., Novak, I., & Herbert, R.D. (2011). Modified constraint-induced therapy for children with hemiplegic cerebral palsy: a randomized trial. *Developmental Medicine& Child Neurology*, 53, 1091-1099. DOI: 10.1111/j.1469-8749.2011.04086.x.
- Watson, L., F. Stanley, et al. (1999). Report of the Western Austrian Cerebral Palsy Register - To birth year 1994. Perth, TVW Telethon Institute for Child Health Research.

## Appendix 1.

1. Cerebral Palsy/
2. cerebral palsy.mp.
3. 1 or 2
4. Hemiplegia/
5. (spastic hemiplegi\* or infantile hemiplegi\*).mp.
6. 4 or 5
7. 3 and 6
8. (physical therap\* or constraint induced therap\* or gait training or rehabilit\*).mp.
9. exp Physical Therapy Modalities/
10. cerebral palsy/rh
11. 8 or 9 or 10
12. Time Factors/
13. (time or timing).mp.
14. 12 or 13
15. child\*.mp.
16. infant\*.mp.
17. 15 or 16
18. 7 and 11
19. 14 and 18
20. 17 and 18
21. 19 or 20
22. limit 21 to yr="1995 -Current"