Critically Appraised Topic

Title: There is moderate evidence that a low dose of CIMT (defined as 3 hours/day or less) is at least as effective as the traditional protocol involving 6 hours/day in improving upper extremity motor function in children with unilateral cerebral palsy.

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CLINICAL SCENARIO

Condition/Problem:

Cerebral Palsy is a group of developmental motor disorders of the central nervous system arising from a non-progressive lesion of the brain. Brain damage leading to cerebral palsy can result from the interaction of multiple factors. It is typically caused by injury to the brain at birth, during the early stages of development in the womb, or during the first two years of life (Perlman, 1997). Prenatal factors include congenital abnormalities (Pharoah, 2007) or maternal health factors such as smoking (Streja et al., 2013), exposure to alcohol (O'Leary, Watson, D'Antoine, Stanley, & Bower,. 2012), and high pre-pregnancy maternal BMI (Forthun et al., 2016). Other causes include a lack of oxygen at birth (Perlman, 1997), multiple births (Bonellie, Currie, & Chalmers, 2005), or an infection affecting the mother and the developing fetus (Streja et al., 2013). Infants who are born prematurely or with a low birth weight are especially susceptible to cerebral palsy (Hirvonon et al., 2014).

Individuals with Cerebral Palsy may experience muscle weakness, a lack of muscle tone, unsteady walking (Givon, 2009) muscle spasticity, abnormal reflexes, involuntary movements (Poon, & Hui-Chan, 2009), abnormal posture, and lack of coordination (Stevens, 2005). In severely affected individuals, an attempted voluntary movement may evoke a primitive reflex, co-contraction of agonist and antagonist muscles, and mass movements (Glader & Barkoudah, 2017).

The motor disorders of cerebral palsy are often accompanied by disturbances of sensation, cognition, communication, perception, and behaviors (Stevens, 2005). Other associated conditions may affect vision, hearing, language, cortical sensation, attention, and vigilance. Some children may have epilepsy, and many have disturbed gastrointestinal growth and function. Agnosias and dyspraxias may interfere with the completion of skilled tasks such as ADLs and IADLs (Glader & Barkoudah, 2017). Research has also found that infants diagnosed with CP are also less adaptable, less persistent and more withdrawn from stimulation (Ross, 1987).

Incidence/Prevalence:

Cerebral palsy is the most common cause of physical disability in childhood (Pellegrino, 2007). Approximately 3.6 in 1,000 children are diagnosed with cerebral palsy (10,000 new cases in the United States each year) and about 30% of these are diagnosed with spastic unilateral cerebral palsy (Roper & Samuels, 2009). Studies have also found that African American children have a 52% higher risk of spastic CP than Caucasian children, and identify socioeconomic status and perinatal factors as reasons for this association (Durkin et al., 2015). The prevalence of CP is far higher in preterm compared with full term infants, and increases with decreasing gestational age and birth weight (Barkoudah & Glader, 2017). As shown in epidemiologic studies of children with cerebral palsy, approximately 25% were <32 weeks; 10-20% were 32 to 36 weeks; and 60% were born >36 weeks (Hirvonon et al., 2014).

Impact of the Problem on Occupational Performance:

Children with cerebral palsy often experience muscle stiffness in the upper and/or lower extremities along with jerky movements. When a child with spastic cerebral palsy attempts to move, muscle tone increases and then rapidly releases, triggering a hyperactive stretch reflex in the muscle. This spasticity is associated with poor control of voluntary movement and limited ability to regulate force of movement (Poon, 2008). Therefore, spasticity can lead to difficulty with dressing both the upper and lower extremity, bathing, using the bathroom, eating, drinking, writing and holding objects.

Cerebral palsy will also typically lead to difficulty achieving and maintaining posture while lying down, sitting, and standing because of impaired patterns of muscle activation (Stevens, 2005). This lack of stable posture results in a decreased ability to complete functional activities with the upper limb due to the dependability of distal mobility on proximal control and dynamic stability. A lack of posture will result in challenges completing functional activities, including object play, social play, self-care, and educational activities (Case-Smith, DeLuca, Stevenson, & Ramey, 2012)

Depending on the location of the lesion on the brain, a child with cerebral palsy may also experience cognitive deficits, inattention, trouble with organization, difficulty problem solving, along with language and speech deficits (Nordberg, Miniscalco, Lohmander, & Himmelmann, 2013). These deficits may affect the child's ability to produce speech, and may have a significant impact on the child's ability to participate in age appropriate activities with peers, understand directions, and manage their own occupations.

Lastly, children with cerebral palsy may have visual or sensory impairments. Visual impairments include blindness, uncoordinated eye movements, and eye muscle weakness, or may mean the child has a deficit in the way the brain processes visual information (Lew et al., 2015). These visual impairments may affect the child's ability to complete fine motor tasks, such as writing, play, and activities that require grasp and release, manipulation of objects, or making eye contact. Additionally, children with cerebral palsy may demonstrate difficulty processing tactile and proprioceptive information. This results in difficulty understanding and responding to social and physical environments, and sometimes leads to oral tactile sensitivity. A child with an aversion to certain food textures or disorganized oral motor control problems coordinating chewing, sucking, and swallowing, may negatively affect the child's ability to eat and drink.

Intervention:

Constraint induced movement therapy is an intense burst of treatment that occurs within a short time period, typically around 21 days (Allgier, 2008). The intervention involves constraining the stronger upper extremity, causing forced use of the affected, or weaker, extremity (DeLuca, Case-Smith, Stevenson, & Ramey, 2012). Constraining methods vary; however, the literature reviewed for this project defined the constraint as a uni-valved cast that went from the child’s upper arm to the end of the finger tips (DeLuca et al., 2012). This constraint was worn for 24 hours a day throughout the treatment, but was removed once a week by the therapist for skin checks. The child takes part in an intense therapy protocol that involves up to 6 hours a day of occupational therapy services (Case-Smith, DeLuca, Stevenson, & Ramey, 2012). The therapist provides increasingly difficult activities or tasks for the child to complete according to their progress. Specific, positive feedback is used to reinforce the child’s movements in an attempt to “shape” their movements into a typical movement pattern. The first 18 days of treatment focus on unilateral exercises involving the affected extremity, and bilateral exercises are emphasized on the final 3 days following cast removal (Case-Smith et al., 2012).

Previously, the protocol has been 6 hours/day; however, this intervention was researching the effects of different dosages for children. Two interventions were explored: one with the previous six-hour protocol, and one with a 3 hour/day protocol (Deluca et al., 2012).

OT Theoretical Basis:

Constraint induced movement therapy, or CIMT, is supported by the contemporary motor learning and control theory. Motor learning refers to the development and refinement of movement patterns over a length of time, and motor control is the outcome that results in movement that is purposeful (Poole, 1991). A major tenet of this theory is the concept of brain plasticity, which is the brain’s ability to develop new pathways around the injured area of the brain. These new pathways allow the individual to regain functional movement and increase occupational performance. The contemporary model states that motor learning stems from the interaction between the person and their environment; therefore, tasks to promote motor learning recovery should be task oriented (Mathiowetz & Haugen, 1994).

Motor learning is impacted by multiple factors, including the feedback received, the task, and how the task is practiced (Poole, 1991). CIMT is hypothesized to cause the brain to make new pathways through the forced use of the involved extremity in multiple tasks over long periods of time. Overcoming the learned non-use of the affected limb takes place after careful shaping of motor behaviors by gradually increasing the complexity of the task as the patient progresses. Throughout the intensive therapy, patients are provided with extrinsic feedback from the therapist to encourage correct movement patterns, as well as intrinsic feedback from the affected limb during the movement. The shaping of movement should be completed using functional and meaningful tasks (Mathiowetz & Haugen, 1994). The combination of repetitive practice over multiple tasks guided by feedback is believed to be what causes improvement following CIMT, which can be related to the major tenants of the motor learning theory.

Science Behind Intervention:

Mechanism of Change

CIMT of the upper extremity in children with cerebral palsy is thought to reduce a phenomenon called learned non-use (Cope et al., 2010) or developmental disregard. Because the impaired upper extremity is inefficient and potentially frustrating to use, the child instead becomes accustomed to ignoring the hemiplegic arm and using the unimpaired upper extremity (Cope et al., 2010). It is thought that massed practice, or large numbers of subsequent movement repetitions, can both counteract learned non-use and improve motor function (Cope et al., 2010). It has also been discovered that CIMT leads to cortical reorganization (Cope et al., 2010); Sutcliffe et al. (2007) report that "[c]onstraint therapy and modified constraint therapy may work through behavioral changes, cortical changes, or both" (p. 1281). Specifically, it has been proposed based on fMRI taken before and after CIMT that this cortical mechanism for improved hand function may be an increase in sensory input to contralateral somatosensory cortex (Sutcliffe et al., 2007).

Key Aspects of Intervention

1. Constrain unimpaired UE
2. Repetitive and intense motor activity practice
3. " . . . shaping of more complex, functional motor acts by breaking the desired task into its component movements and rewarding successive approximations to the target task" (Brady & Garcia, 2009, p. 102).

Why Intervention Appropriate for OT:

In occupational therapy, constraint-induced movement therapy serves as an activity that encourages functional use of the child's hemiplegic upper extremity to facilitate performance of bimanual occupations or occupations requiring just the affected upper extremity. CIMT classifies as an activity in the OT framework when used with a pediatric population because although the child is being prompted to do perform repetitive movements, these movements are all components of the larger occupation of play and are meaningful to the child. For example, the protocol used by Taub, et al. (2004) requires " . . . presenting interesting and useful activities to the child in ways that provide immediate, frequent, and repetitive rewards . . ." (p. 36).

In the use of CIMT, occupational therapists incorporate repetitive
practice into meaningful, functional activities for children (Brady & Garcia, 2009). Target occupations of CIMT activities could include ADLs such as bathing/showering, toileting, dressing, feeding, or personal hygiene and grooming; IADLs such as care of pets; formal education participation; and play exploration and participation. In addition, because CIMT involves shaping, or rewarding successive approximations toward functional movements, eventually the CIMT itself may consist of cohesive occupational performance, such as eating with the impaired hand, rather than activities (Brady & Garcia, 2009). When the CIMT is integrated into the home environment, it becomes an occupation as the child carries out their everyday routines.

FOCUSED CLINICAL QUESTION

Does a “high” dose of CIMT lead to significantly greater use of the affected UE in children with CP than a “low” dose* of CIMT following 3 weeks of treatment?

*high dose means 4 or more hours per day while low dose means 3 or less hours per day

SEARCH SUMMARY

Literature reviewed for this critically acclaimed topic was located using Uptodate, Clinical Key, Medline, Cinahl, and GoogleScholar. Eight studies were located that included relevant information related to the clinical question. Two randomized control trials and one pilot study were selected to be critiqued. Articles were chosen for inclusion based on intervention used, varying treatment dosages, and population tested.

CLINICAL BOTTOM LINE

There is moderate evidence that a low dose of CIMT (defined as 3 hours/day or less) is at least as effective as the traditional protocol involving 6 hours/day in improving upper extremity motor function in children with unilateral cerebral palsy.

Limitation of this CAT: This critically appraised paper (or topic) has been reviewed by occupational therapy graduate students and the course instructor.

TABLE 1: SEARCH STRATEGY

Search Terms	Inclusion and Exclusion Criteria
Constraint Induced Movement Therapy Cerebral Palsy Pediatrics Dosage "Constraint Induced Movement Therapy" AND Cerebral palsy "Constraint Induced Movement Therapy" AND "Cerebral palsy" AND "paediatrics" "Constraint induced movement therapy" OR "CIMT" AND Cerebral palsy "Constraint induced movement therapy" AND "cerebral palsy" AND "dosage" "Modified constraint induced movement therapy" AND "Cerebral palsy" AND "Pediatrics"	Inclusion: Published 2007 or later Children with unilateral cerebral palsy Articles that discussed differences in dosage Exclusion: Published prior to 2007 Adults Children without unilateral CP

TABLE 2: SUMMARY OF STUDY DESIGNS OF ARTICLES RETRIEVED

Level	Study Design/ Methodology of Articles Retrieved	Total Number Located	Citation (Name, Year)
1a	Systematic Reviews or Metanalysis of Randomized Control Trials	1	(Chiu, 2016)
1b	Individualized Randomized Control Trials	4	(Choudhary, 2013) (Charles, 2006) (DeLuca, 2012) (Case-Smith, 2012)
2a	Systematic reviews of cohort studies		
2b	Individualized cohort studies and low quality RCT's (PEDro ≤4)		
3a	Systematic review of case-control studies		
3b	Case-control studies and non-randomized controlled trials (quasi experimental or clinical trials)		

4	Case-series and poor quality cohort and case-control studies	1	(Lowes, 2014)
5	Expert Opinion	2	(Christman, 2015) (Mancini, 2013)

STUDIES INCLUDED

	Study 1 Deluca, Case-Smith, Stevenson, & Ramey (2012)	Study 2 Case-Smith, Deluca, Stevenson, Ramey (2012)	Study 3 Lowes, Mayhan, Batterson, Tonneman, Meyer, et al. (2014)
Design	Multi-site randomized control trial	Multi-site randomized control trial (6 month follow up)	Before and after
Level of Evidence	1b	1b	4
Rigor Score	8/11 on PEDro Scale	8/11 on PEDro Scale	Not a randomized control study
Population	18 children (10 boys, 8 girls) ages 3-6 with unilateral cerebral palsy	18 children (10 boys, 8 girls) ages 3-6 with unilateral cerebral palsy	Seven infants ages 6 to 18 months with a diagnosis of unilateral cerebral palsy
Intervention Investigated	Constraint Induced Movement Therapy (CIMT) for 6hrs/day for 21 days with 24/7 casting of the unimpaired arm. Followed by 3 days of therapy focusing on bimanual activities after cast removal.	Constraint Induced Movement Therapy (CIMT) for 6hrs/day for 21 days with 24/7 casting of the unimpaired arm. Followed by 3 days of therapy focusing on bimanual activities after cast removal.	Constraint induced movement therapy for 2hrs/day by an occupational therapist and 1hr/day by the parent with 24/7 casting of the unimpaired arm. Interventions focused on functional tasks, play and sensory activities and strength building that emphasized use of affected UE. Followed by 4 days of bimanual therapeutic activities after cast removal.
Comparison Intervention	Constraint induced movement therapy for 3hrs/day for 21 days with 24/7 casting of the unimpaired arm. Followed by 3 days of therapy focusing on bimanual activities after cast removal.	Constraint induced movement therapy for 3hrs/day for 21 days with 24/7 casting of the unimpaired arm. Followed by 3 days of therapy focusing on bimanual activities after cast removal.	Occupational Therapy Treatment ("usual care") 1 hr per week in an outpatient clinic for four weeks. Interventions focused on functional tasks, play and sensory activities, strength building, and bilateral

			activities. The unaffected arm was not constrained during this portion of the study.
Dependent Variables	-Upper extremity (UE) functioning of the affected limb -Parent report of child's impaired UE use	-Upper extremity (UE) functioning of the affected limb -Parent report of child's impaired UE use	-Fine and gross UE motor performance (prehension, motor planning, grasp, eye-hand coordination) -Parent perceptions of how well and how often infant used affected arm
Outcome Measures	-Assisting Hand Assessment (AHA) -Shriner's Hospital Upper Extremity Evaluation (SHUEE) -Quality of Upper Extremity Skills Test (QUEST) -Pediatric Motor Activity Log (PMAL)	-Assisting Hand Assessment (AHA) -Shriner's Hospital Upper Extremity Evaluation (SHUEE) -Quality of Upper Extremity Skills Test (QUEST) -Pediatric Motor Activity Log (PMAL)	-Bayley Scales of Infant and Toddler Development -Infant Motor Activity Log
Results	-Statistically significant increase (p=.001) on AHA -Statistically significant increases in dynamic positional analysis and spontaneous functional analysis (p=.001 and p=.01 respectively) -Statistically significant increase (p=.001) in dissociated movement -Statistically significant (p=.001) for grasp -No significant differences between site, dosage, or time	-Children in both dosage groups showed significant improvement across time after receiving the intervention -Scores increased on both the AHA and QUEST (p<.01) -PMAL how well (p < .001) and how often (p=.001) reflected significant improvement. -Significant improvement was maintained at six month follow up -No significant differences between dosage	- CIMT produced statistically significant increase on BSID fine motor scale for affected arm -Improvement on the BSID gross motor scale was significant for the CIMT phase and the follow-up retention phase -IMAL parent questionnaire scores improved significantly over the course of treatment and significantly correlated with the BSID scores
Effect Size	.36 for PMAL "how well" .76 for QUEST dissociated movement .78 for AHA	Ranged from .34-.63	Not Reported
Conclusion	The study concluded that participants in both groups achieved comparable and significant functional improvement; therefore, a	Low-dosage pediatric CIMT (3hr/day) is an effective intervention producing clinically significant improvements	CIMT has positive effects in infants with unilateral CP, and further controlled clinical trials

	newer 3hr/day protocol may be sufficient for CIMT in children with CP.	in upper-extremity function in young children with unilateral CP. -Although effects were slightly diminished at 6 month compared with those immediately post intervention, the changes were not statistically significant, and moderate to high-level effects were sustained. The similar effects of low- and high-dosage CIMT are maintained for 6 months.	are needed with larger sample and follow-up.

SYNTHESIS SECTION

PICO Question:

Does a “high” dose of CIMT lead to significantly greater use of the affected UE in children with CP than a “low” dose* of CIMT following 3 weeks of treatment?
*high dose means 4 or more hours per day while low dose means 3 or less hours per day

Overall Conclusions:

Variables

Upper Extremity Movement Variables: Upper extremity client factors that were measured included dissociated movement, grasp, fine motor function, upper extremity bimanual function, as well as the parent's perception of quality and frequency of upper extremity movements.

Outcome Measures

- Assisting Hand Assessment (AHA)
  - Ability to use affected hand in combination with unaffected hand
  - Construct Validity: Item fit statistics showed that items measure a single construct
  - Reliability: standard error mean (.28) suggests good reliability (Krumlinde-Sundholm & Ann-Christin Eliasson, 2003)
- Quality of Upper Extremity Skills Test (QUEST)
  - Quality of UE movement (dissociated movement and grasp)
  - Test-Retest Reliability: excellent (ICC=.95)
  - Inter-Rater Reliability: excellent (ICC=.91-.96)
  - Internal Consistency: excellent (Cronbach's alpha=.97)
  - Construct Validity: good (r=.84) (Beard, 2016)
- Pediatric Motor Activity Log (PMAL)
  - Parent's perception of quality and frequency of use
  - Test-Retest Reliability: excellent (ICC=.93-.94)
  - Construct Validity: " . . . sound evidence for unidimensionality" using Rasch analysis (Wallen, Bundy, Pont, & Ziviani, 2008)
- Bayley's Scale of Infant Development (BSID)
  - Prehension, motor planning, grasping patterns, eye-hand coordination

  - Not intended to be an outcome measure
  - Internal Consistency Reliability: good (ICC=.86 [fine motor]-.91 [gross motor])
  - Test-retest Reliability: good (ICC=.83)
  - Construct Validity: moderate (ICC=.49-.57 with Peabody Developmental Motor Scales; ICC=.58-.7 with Vineland Adaptive Behavior Scale—Interview Edition) (Albers & Grieve, 2007)
- Shriner's Hospital Upper Extremity Evaluation (SHUEE)
  - UE bimanual functioning
  - Intra-observer Reliability: excellent (ICC=.99)
  - Intra-rater Item Reliability: excellent (ICC=.89-1.00)
  - Concurrent Validity: moderate (ICC=.47 with Pediatric Evaluation of Disability Inventory) (Deluca et al., 2012)

Results

- In the study conducted by Deluca et al. (2012), the group receiving a decreased dosage and the group receiving a traditional dosage of CIMT showed the same effect size. Specifically, both the 3- and 6-hour/day groups showed strong effect size (eta squared ranged from .36 [PMAL] to .78 [AHA]) and no significant difference was found between the groups.
- Case-Smith et al. (2012) found that both the 6-hour/day and 3-hour/day CIMT interventions resulted in a similar strong effect size (partial eta squared ranged from .33 [QUEST Dissociated Movements] to .80 [PMAL How Well]) at the 6-month follow-up, suggesting the dosages have a similar strong effect lasting at least 6 months.
- The pilot by Lowes et al. (2014) study investigating the effects of 1 month reduced-dosage CIMT (2 hours therapist-directed, 1 hour parent-directed therapeutic activities per day) found, based on limited outcome measures, statistically significant improvements in fine motor and gross motor abilities. This study supported the potential of CIMT in increasing UE motor skills in 7- to 18-month-old infants with CP, but outcome measure limitations and small sample size must be considered.

Similarities

- Intervention: Deluca et al., (2012), Case-Smith et al., (2012), and Lowes et al., (2014) all received constraint induced movement therapy as the main intervention. CIMT interventions across all three studies were similar in that they included specific and structured tasks that emphasized functional, play-based activities that encouraged the use of the impaired upper extremity. Following the CIMT stage with casting, both groups received 3-4 days of treatment that focused on bimanual upper extremity functioning.
- Variables: All three studies measured outcome variables that included functioning of the impaired upper extremity, as well as bimanual upper extremity functioning.
- Constraint Method: Deluca et al., (2012) and Lowes et al., (2014) indicated that casting of the unimpaired upper extremity for 24 hours a day was the method of constraint.
- Data Collection: Deluca et al. (2012) and Lowes et al. (2014) measured outcome variables before the start of intervention, after the completion of the intervention, and then again 1-month post intervention. Deluca et al., (2012), and Case-Smith et al., (2012) compared the moderate and high dosages of CIMT using date from the same participants.

Differences

- Two of our studies differed with respect to treatment dosage and treatment protocol, whereas the third study differed by considering the maintenance of effects over time.
- Treatment Dosage: Deluca et al., (2012) compared a high dosage of CIMT (6 hr/day or 126 hours) with a low dosage (3 hr/day or 63 hours) over 21 days. Lowes et al., completed 3 hours (69 hours total) of CIMT daily over 23 days.

- Treatment Protocol: Studies differed in treatment protocol in that the Deluca et al., (2012) casted the unaffected arm for the first 18 days while engaging the child in occupations that would improve unimanual skills. During the final 3 days the cast was removed and sessions focused on integrating the child's unilateral skills into bimanual activities. The Lowes et al., (2014) study casted the participants for the first 23 days and bimanual therapy was provided for the last 3 days.
- Who Implemented the CIMT: In the Lowes et al., (2014) study the participants received 2 hours of occupational therapy from an occupational therapist and 1 hour of the parent-implemented home program. Deluca et al., (2012) had occupational therapists applying all of the standardized CIMT protocol. These differences between studies in treatment dosage and treatment protocol did not have significant effects on the findings.

Boundaries:

There was total of 23 participants (12 males, 11 females, ages 6 months to 6 years) between the three studies that completed the CIMT intervention; however, 3 participants were lost at the 6 month follow up study. All participants had a diagnosis of unilateral cerebral palsy (CP). One study required that participants were diagnosed with a brain lesion prior to one month of age; however, the pilot study had no further inclusion criteria beyond a diagnosis of unilateral CP. Exclusion criteria included the use of botox within the last 6 months, previous participation in a formal CIMT program, presence of uncontrolled seizure disorder, visual impairment, orthopedic deformity of the upper extremity, comorbid medical condition, or a family that was unable to complete the protocol.

Implications for Practice:

- These studies demonstrated that CIMT produced statistically and clinically significant improvement in upper extremity functioning in children with unilateral CP.
- Research suggests that a moderate dosage of CIMT (3 hrs/day) may be sufficient to see statistically significant improvements in functioning, and that the high dosage (6hrs/day) may not provide any additional benefits.
- Further research is necessary to supplement these results, due to the limitations of small sample sizes and variability of participant's baseline functioning in the included studies.
- Key aspects of the CIMT protocol appear to be the constraint of the unaffected arm, daily use of the effective arm, therapy that focuses on practice and challenges, immediate reinforcement of performance, and learning in the child's natural environment.
- The findings of this research also suggest that the effects of reduced-dosage CIMT are maintained over time and comparable to effects of the traditional dosage.
- Future research should be completed to evaluate the qualitative effects of low dosage CIMT on the parents and children involved.

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