THERAPEUTIC EFFECTS OF CONSTRAINT INDUCED MOVEMENT THERAPY VS BIMANUAL TRAINING IN CHILDREN WITH CEREBRAL PALSY: A SYSTEMATIC REVIEW

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ABSTRACT:
Constraint Induced Movement Therapy (CIMT) and Bimanual training (BIT) have been shown to improve function of the affected upper extremity of children with spastic hemiplegic cerebral palsy. Purpose: The purpose of this review is to understand the utilization and therapeutic effects of CIMT vs. BIT, while indicatingpossible factors influencing the efficacy of the interventions. Method: An analysis was conducted between the years of 2015 to 2016 utilizing multiple medical databases. Results: Twelve articles were used in this study for the systematic review based off of the inclusion criteria. Conclusions: Overall CIMT and BIT have been shown to have significant effects on increasing function especially when combined with different factors such as environment, frequency, and age when compared to standard therapy treatments. Clinical application:Understanding the interaction between the aforementioned factors can help guide clinicians toward the most time and cost effective treatment techniques in order to improve the functional outcome of children with cerebral palsy. This knowledge may be useful in developing future modifications to existing practice to improve the overall quality of life during the developmental years of this population.

Keywords: Cerebral Palsy; Constraint Induced Movement Therapy; Bimanual Therapy; Children; home environment; Infants

INTRODUCTION

Cerebral Palsy (CP) is a disorder that may occur in utero, during, or shortly after that affects one in five hundred live births. Of this statistic, 35% present with hemiplegia which results in functional deficits and stunted development on the ipsilateral upper and lower extremity with increased involvement of the upper extremity.1Studies have shown that CIMT and BIT are effective in improving functionality of children especially with intervention of treatments early in life. CIMT is a therapeutic technique in which a therapist restrains the uninvolved upper extremity to prompt the use of the effected extremity.2BIT sometimes referred to as HABIT (Hand Arm Bimanual Training), is an approach that targets the use of both upper extremities to complete functional tasks. HABIT focuses on the child's specific functional deficits and incorporates the child's interests into activities.3The purpose of the systematic review was to examine the efficacy of CIMT and BIT in the treatment of hemiplegic CP. Further analysis was performed in order to examine the effects of frequency, age, and environment on overall functional outcome and improvement on fine motor skills.

METHODOLOGY

Multiple searches were conducted using3 databases. These databases includedPEDro, CINAHL, and Medline.Initial searches were conducted between October 2015 to November 2015 with updated searches performed in March 2016, and September 2016. Six search terms were used to retrieve information regarding CIMT and BIT. See Figure 1 below for further detail. In total, 18 searches were conducted and a total of 187 articles were found. Assessment of articles were completed through the PEDro scale and level of evidence scale in which level 4 or 5 articles were not accepted.4 Language was not an issue as all the articles studied were accessible in English. Initial searches used articles published between 2010 and 2015 with updated articles including articles from 2016. Study selection was based on search terms and relevance of the information. Data extraction for this study included assessing different factors such as environment, frequency, and age in which the studies took place.

RESULTS

With the search terms (refer to Figure 1 for specific terms used) and inclusion criteria provided,twelve articles were analyzed in the systematic review. No duplicates were found.Figure 2 depicts the PEDro score of each article.5 The average PEDro score for the articles included were 5.91. One article was excluded from this average as it was a case study and could not be scored using the PEDro scale. When searching for research articles, certain articles provided information regarding CIMT vs BIT but with further analysis of the abstract, it

showed the primary participants were adults, which excluded the article from the systematic review. The level of evidence ranged from level 1 to level 3. Of the twelve articles, ten articles were level 1 randomized control trials, one article was a level 2b cohort study, and one article included a level 3 case study.Appendix A represents the articles that were included in this study.

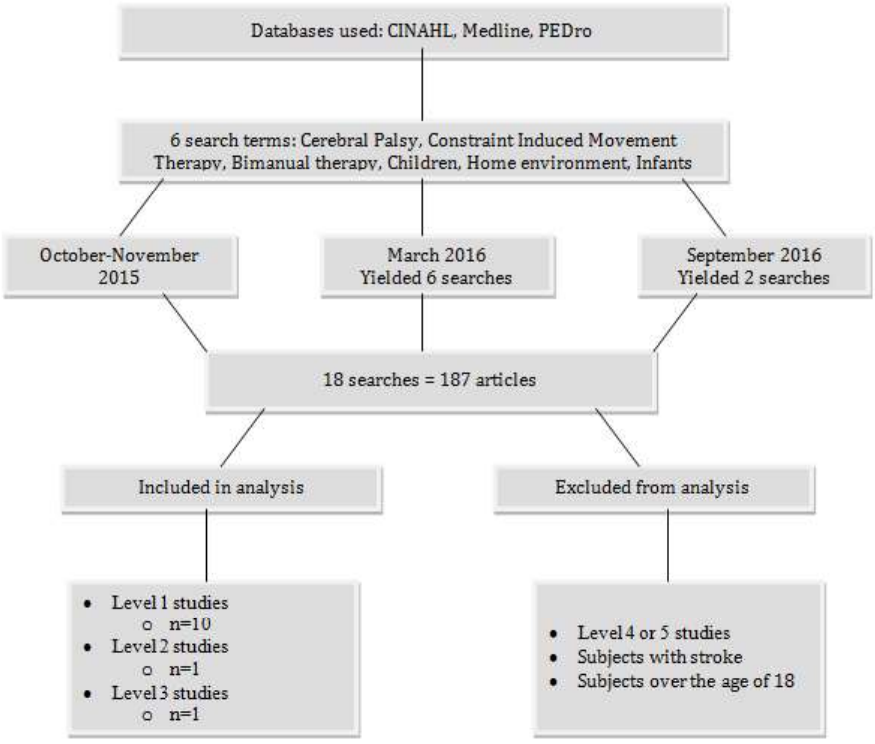

Figure 1. Search Strategies

DISCUSSION

Evidence of use of CIMT and BIT demonstrate that they have significant effects on children with hemiplegic cerebral palsy. Using a quality of life questionnaire to assess children's self-perceived feelings of function and participation in tasks, Sazewski determined that CIMT and BIT influenced changes in the affected upper limb, improving the child's overall quality of life.1Additionally, a study by Aarts also provided evidence for the use of modified-CIMT in combination with BIT to improve upper limb function.6 This study found that children who participate in CIMT or BIT may make better use of already created motor capabilities in the involved upper limb, instead of trying to regain activity of the muscle groups.6

As a result of the literature research, the article searches also revealed some differences in CIMT and BIT. A group of participants who received CIMT had more ability to grasp, and displayed dissociated movements after the intervention, as indicated by scores on the QUEST, (Quality of Upper Extremity Skills Test), outcome measure.2,7 According to Gordon, bimanual therapy has been indicated to have participants progress towards their goals more efficiently and at a quicker rate than CIMT.8 This indicates better outcomes for participants who set goals that are important to them while receiving BIT.8 BIT was also helpful in increasing the likelihood of more unprompted and more naturally occurring use of the affected limb during play.7 With further analysis of articles, overlying consistencies were found between the data gathered and other influences playing a role in the efficacy of therapeutic approaches. These factors included environment, frequency, and age. Figure 3 displays the breakdown of articles included and the participants per factor.

Figure 2 PEDro Table

	Gelkop 2015	Gordon 2011	De Brito Brandão 2012	Deppe 2013	Facchin 2011	Sakzewski 2013	Aarts 2011	Geerdink 2013	Zafer 2016	Rostami 2012	Shetty 2014	Lowes 2014
Eligibility criteria were specified***	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	n/a	Yes
Subjects were randomly allocated to groups	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	n/a	No
Allocation was concealed	Yes	Yes	Yes	Yes	No	Yes	No	No	Yes	No	n/a	No
The groups were similar at baseline regarding the most important prognostic indicators	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	n/a	Yes
There was blinding of all subjects	No	No	No	No	No	No	No	No	Yes	No	n/a	No
There was blinding of all therapists who administered therapy	No	No	No	No	No	No	No	No	No	No	n/a	No
There was blinding of all assessors who measured at least one key component	Yes	Yes	No	Yes	No	No	Yes	No	No	Yes	n/a	No
Measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	n/a	Yes
All subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analyzed by "intention to treat"	Yes	No	No	No	No	Yes	No	Yes	Yes	No	n/a	Yes
The results of between-group statistical comparisons are reported for at least one key outcome	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	n/a	No
The study provides both point measures and measures of variability for at least one key outcome	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	n/a	Yes
Total PEDro Score	8	7	6	7	4	7	6	6	5	5	n/a	4

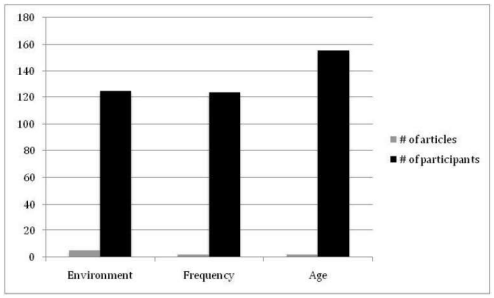

Figure 3. Breakdown of Number of Articles and Participants per Factor

	# of articles	# of participants
Environment	5	124
Frequency	2	123
Age	2	155

Environment

Of the 12 articles, 3 articles focused on a home-based setting where other articles focused on a clinical setting with a component of the treatment completed at home. The last couple of articles focused on a school or day camp setting. Results showed that interventions are more beneficial in a home based setting especially BIT due to the fact that it focuses on the child's interests and incorporates it into their treatments. "Providing therapy in the child's typical environment can have important positive effects on his/her motor development. The motor learning framework suggests adapting the environment as a way to elicit changes in motor behaviors."9Studies showed that children were more likely to use their affected hand at home due to the fact that they were in a more natural environment performing functional activities such as cooking, performing chores, and dressing up.10 A possible explanation for this finding could be an increased level of comfort for the child. Home-based therapy provides integration of therapeutic approaches that are parallel to household chores vs non meaningful activities that may be completed in a clinic based setting.

In a study by Geerdink et. al, children in a standard therapy (ST) group received treatment at home and at school.11 Comparisons were made between the ST group and the CIMT/BIT group and found that children in the ST group did not make as much of an improvement as the CIMT/BIT group. This may provide some evidence that a combination of CIMT/BIT and a home based approach may both contribute to a greater overall improvement.11

In a study analyzing school based therapy, school based settings indicate a gradual increase in function for both CIMT and BIT groups. From the results found in different types of settings, similar outcomes were found between studies when comparing home based therapy and school based therapy.

Outcomes for children in a clinical setting provided similar results of function. However, several studies show that a home based setting is slightly more effective due to level of comfort for the child and practicality in compliance to the therapy session. Thus, these various studies indicate a need for a home therapy program in conjunction with a clinic or school based therapy program.

Home based settings allow for a family centered approach demonstrating significant improvement in fine motor and gross motor skills in children with cerebral palsy.12 In the article by Rostami, the home program made attempts to involve the child, the parent, and the therapist through selecting activities that meet common goals.10However, this study indicated that mCIMT is better for isolated functions of the affected arm compared to BITwhich displayed more effectivenessof spontaneous hand use in real life situations.13

Frequency

When reviewing duration of treatment using the QUEST, there was really no apparent difference in results. In the studies conducted by Zafer providing treatment over two weeks and a study completed by Facchin providing treatment over a ten week period, there was no substantial differences in the overall outcome.2,6 Both studies usedQUEST scores when looking at dissociated movements and protective extension. After reviewing another common outcome measure, Assisting Hand Assessment, no specific treatment duration demonstrated one as superior to another.

Age

In the study conducted by Facchin, although the results were not statistically significant, the data appeared to show that the younger children made greater improvements in ADLs when using the BIT approach.7A study conducted by Geerdink with a duration of 6 weeks of CIMT and 2 weeks of BIT found that children five years or younger were able to reach maximum potential by the sixth week with modified constraint induced movement therapy (mCIMT).11 Children five years or older took longer to reach their maximum gain not reaching this level until the seventh or eighth week. This study suggests that children five years and older may benefit from a longer period of mCIMT. Although, other studies concluded that age was not a significant contributor to the results.11

Limitations

When conducting the preliminary article search for this study, many articles did not utilize a control group limiting the ability to observe the effect of the intervention. There werefew articles that looked at a comparison between the environmental settings of treatment. Some of the contributing factors such as environment, frequency, and age were not well researched, and that made it difficult to draw comparisons. When these contributing factors were researched, there were often occasions of conflicting data, even though some of this conflicting data was not statistically significant. Of the articles included in this study, many were comprised of a small sample size which could limit the external validity of this study.

A promising pilot study was found, and the researchers were contacted to obtain further information regarding the study.14 Time restraints and lack of communication prevented the utilization of the pilot study results in this study, however important findings were included in Appendix A.

Strengths

According to Gordon et al, it is important and somewhat necessary to create individualized programs for overall well being of the participant.8A strength discovered in this review method was the individualized care and therapeutic treatment of participants in the studies with small sample sizes which allowed for a more individualized outcome. Another strength of this study was the ample amount of articles available on the topic of pediatric cerebral palsy, and therefore it was possible to analyze each article to find factors which can influence therapeutic efficacy.

CONCLUSION

In conclusion, as a result of this systematic review, it appears that the best therapeutic approach is home-based therapy

utilizing either CIMT or BIT at a younger age, with an unspecified frequency (summarized in Figure 4). Future research may be necessary to fully understand the effects of environment, frequency and age. When examining the overall outcomes of CIMT versus BIT, evidence indicates that CIMT is superior when treating unilateral conditions. Conversely, BIT is indicated when treating patients with bilateral conditions.2

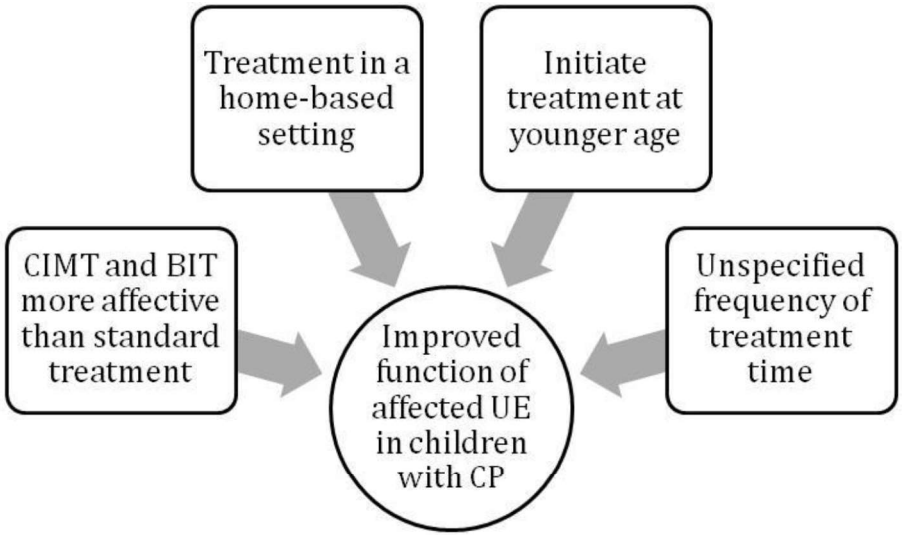

Figure 4. Factors Contributing to Improvements of Affected UE Function

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CLINICAL APPLICATIONS

This information helps identify the appropriate environment, frequency, and age that CIMT and BIT can be effective. Understanding the interaction between the aforementioned factors can help guide clinicians toward the most time and cost effective treatment techniques in order to improve the functional outcome of children with cerebral palsy. This knowledge may be useful in developing future modifications to existing practice to improve the overall quality of life during the developmental years of this population.

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Appendix A

Question: What is the effect of CIMT and BIT for treating an affected UE in children with Cerebral Palsy?								
	Study		Methods				Reviewer Comments	
Citation	Study Type (LOER)	Pedro Score	Subject # and groups	Intervention	Assessment Tool	Outcomes	Limitations	Conclusion
Gelkop 2015	*Randomized controlled trail (1)	8	*12 children between the ages of 1.5 and 7 years with hemiplegic CP *6 children receive CIMT *6 children receive BIT	*administered during the children's normal school day *Each child received 2 hours of therapy 6 days a week for 8 weeks ***CIMT group-** children wore custom gloves on the unaffected UE and performed fine motor and gross motor tasks using affected UE ***BIT group-** fine and gross motor bimanual tasks were completed	*AHA measures effectiveness of using affected hand in bimanual activity *QUEST classifies UE function- reach, grasp, manipulation, and releasing activities. *MACS classifies children into 1 of 5 levels based on how they handle objects of daily activities	*Both improved the quality of bimanual hand use and UE function *participants significantly improved following intensive training	*No control group *Small sample size *A 6 month follow up would have been preferred (rather than the 2 month), but the school year did not allow for that to happen	*CIMT may be more beneficial when one to one supervision is not possible- decreases the likelihood of compensation of the unaffected UE
Gordon 2011	*Randomized controlled trail (1)	7	*44 participants randomly assigned to 2 groups- 1 from each group dropped out * Between 3.5 and 10 years of age with hemiplegic CP	* 6 hours a day for 15 consecutive weekdays ***CIMT group-** less affected UE was placed in a sling and then performed fine and gross motor tasks ***BIT group-** no restraints. Children participated in fine and gross motor tasks	*AHA *JTTHF assesses the time it takes to complete a battery of unimanual activities *3 secondary measurements were also used	*Both CIMT and BIT resulted in similar improvements on the AHA and JTTHF *There were significant changes in hand function in both groups *Improvements were achieved in 3 weeks and maintained at the 6 month follow up	*No control group *Shorter treatment duration	*CIMT solely focuses on the use of the affected UE, but it limits the child's ability to do meaningful bimanual tasks
de Brito Brandão 2012	*Randomized controlled trial (1)	6	*16 children with hemiplegic CP *8 in each group- CIMT and BIT	*6 hours a day for 15 days (totaling 90 hours) ***CIMT group-** unaffected arm was put in a sling and motor tasks were preformed with the affected UE ***BIT group-** no restraints were used and children participated in bimanual tasks	*MACS *PEDI scores child's ability to perform ADLs- like self care *Self care was a main focus *COPM defines functional problems that the client feels are relevant and addresses them as goals	*Improvements in functional skills and independence in self-care activities seen in both groups *The BIT group showed greater improvement than the CIMT group only on the functional goal performance scale	*Lack of follow ups to examine retention of acquired skills *Parents weren't blinded to which groups their children were assigned and that could have led to biased functional goals *Goals were only based off of parents' perception of	*Whether using CIMT or BIT, children should practice the functional goals that are deemed important

							important functional goals *Shorter treatment duration	
Deppe 2013	*Randomized controlled trial (1)	7	*47 children with hemiplegic CP or other non-progressive hemiplegia *ages 3 to 12 years were included	*4- 60 minute sessions daily, 5 days a week for a total of 4 weeks ***kid-CIMT group-** Used elastic bandages to restrain unaffected UE. This program is an integrative approach that targets 3 major elements: sensation, mobilization, and activity ***BIT group-** targets the same 3 elements that CIMT targets. Addresses ADLs	*MelbAss evaluates the quality and precision of isolate movement of paretic UE *AHA *PEDI	*Both interventions led to significant improvements of hand function	*Inclusion of non-congenital hemiplegia *Sample size *Lack of long term follow up	*Children with more impairment of the UE may benefit from CIMT
Facchin 2011	*Randomized controlled trial (1)	4	*105 children with hemiplegic CP assigned to 3 groups: 39 children in the mCIMT, 33 in the BIT, and 33 in the standard treatment group (ST) *Children between the age of 2 to 8 years old	*10 week treatment period with a 3,6, and 12 month follow up	*QUEST *Besta Scale assesses the quality of grasp and spontaneous hand use	*Significant differences between the three groups were found on the QUEST Scale as well as the Besta Scale *Both mCIMT and BIT showed improvements in UE function *ST group had minimal improvements *Fine grasp had greater improvement in the mCIMT group vs. the BIT group	*There was a difference between the BIT group and mCIMT group but it was not statistically significant	*BIT may be more useful in developing abilities to complete ADLs
Sakzewski 2013	*Randomized controlled trial (1)	7	*72 children- 36 in each group	*6 hours a day for 2 weeks ***CIMT group-** wore a tailor made glove and wore it for all tasks ***BIT group-** a strategy was adopted from Gordon's study	*CPQOL evaluates the well being of children with CP	*There were improvements, but minimal differences between the two groups	*No control group *Shorter treatment duration	*Both training techniques increased children's perception of well-being

Aarts 2011	*Randomized controlled trial (1)	6	*50 Children with unilateral CP *28 children in the CIMT and BIT group (pirate group) *22 children in the usual care group (UC) *children were between the age of 2.5 and 8 years	*3 hours a week, 3 days a week, for 8 weeks *During the first 6 weeks, children in the Pirate group received CIMT *The last 2 weeks, the Pirate group underwent BIT and completed bimanual tasks	*ROM of the wrist and elbow *VOAA-DDD assessed developmental disregard as well as the capacity and performance of the affected UE	*Study found that improvements may be due to better utilization of motor function rather than muscle strength restoration	*ROM measurements were not taken at the shoulder or trunk, and those measurements may have gone undetected	*Study found that CIMT-BIT group showed improvements
Geerdink 2013	*Randomized controlled trial (1)	6	*50 Children with unilateral CP *28 children in the CIMT and BIT group (pirate group) *22 children in the usual care group (UC) *children were between the age of 2.5 and 8 years	*3 hours a week, 3 days a week, for 8 weeks *During the first 6 weeks, children in the Pirate group received CIMT *The last 2 weeks, the Pirate group underwent BIT and completed bimanual tasks	*Box and Block Test assess manual dexterity *AHA *ABILHAND-Kids is a parent questionnaire evaluating manual skills	*Age had the greatest effect on the speed of dexterity gained during the CIMT period *Children younger than 5 had a 2.3 times greater chance of reaching maximum performance on the Box and Block assessment *Outcomes from the study remained stable at the 6 month follow up	*Learning curve data was based on a small sample size	*Age was found to significantly affect the learning curve
Zafer 2016	*Randomized controlled trial (1)	5	*Started with 20 children, study conducted with 18 children with spastic hemiplegic CP *9 children in CIMT group *9 children in BMT group	*Both groups received 2 hours a day 6 days a week for 2 weeks ***CIMT group-** children used mitt and sling ***BMT group-** no restraints used. *Both groups received personalized ADL task training	*QUEST	*Dissociation movements and grasp were significantly improved in the CIMT group compared to BMT. *No difference in weight-bearing and protective extension between both groups	*Small sample size *Shorter treatment duration	*CIMT is considered an appropriate treatment approach for unilateral conditions while BMT for bilateral conditions.
Rostami 2012	*Randomized controlled trial (1)	5	*14 Children with Spastic Hemiplegic CP *7 children randomly assigned to home group *7 children randomly assigned to clinic group	* Both groups received 15 hours of m-CIMT 3 times a week, for 10 sessions every other day. *Sessions lasted 1 and a half hours *Interventions for both groups were the same, but the environment differed.	*Pre-test, post-test design, and 3 months post treatment *Pediatrics Motor Activity Log *8 (upper limb speed and dexterity) of Bruininks-Oseretsky	*Home environment provided more improvement with m-CIMT. *M-CIMT is effective in improving upper limb function in children with spastic hemiplegic CP. *Home environment provided a more natural context	*Small sample size *Low cooperation of parents and children outside of the research laboratories *Shorter treatment duratio	*Home environment provides a more natural setting to administer m-CIMT

Shetty 2014	*Case Study (3b)	5	*1 participant, 4 y/o girl with unilateral spastic CP	*8 weeks of both interventions for 1 hr. 2 times a week *Child received early intervention since 6 months old. (Freq.- 2 hrs a day, 2 times a week, for 8 weeks)	*Canadian Occupational Performance Measure *Beery Developmental Test of Visual Motor Integration *Bruininks-Oseretsky *Hand Awareness Scale	*No overall change in PROM *Child was able to complete some ADLs	*Because this was a case study, there were no control groups to compare	*While there was no change in PROM the child was able to complete some ADLs *Child was able to stabilize book while writing and erasing, she was able to play with affected limb during fine motor activities, and she was able to pull her pants to mid-thigh with affected limb.
Lowes 2014	*Cohort Study (2b)	4	*5 participants completed treatment protocol	*Usual care treatment for 1 hr a week for 4 weeks *CIMT treatment- casted 24/7 for 23 days 2 hrs of therapy per day *CIMT was followed by 4 days without casting	*Bayley Scale- Gross and Fine motor subscales *Infant Motor Activity Log	*Study indicated the feasibility of infant home based therapy *During CIMT intervention phase, infants demonstrated significant improvement in fine and gross motor, which was maintained at follow up	*Used non-standardized measures *Lack of blinding *Lack of control group *Further research should be completed with more participants	*Findings suggest positive effects for children with unilateral CP

AHA- Assisting Hand Assessment
MACS- Manual Ability Classification System
PEDI- Pediatric Evaluation of Disability Inventory
CPQOL- Cerebral Palsy Quality of Life Assessment for Children
MelbAss-Melbourne Assessment
VOA-DDD- Video Observations Aarts and Aarts module Determined Developmental Disregard

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