Pediatric Constraint-Induced Movement Therapy in the Clinic Setting

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Abstract:

Objective: The purpose of this study was to determine if a ten-day constraint-induced movement therapy protocol is effective for children with cerebral palsy.
Method: A four-year old child with cerebral palsy was put into a 24-hour fiberglass cast for 5 consecutive days, given a two day intermission followed by another 5 consecutive days of casting. He received approximately 15 hours of occupational therapy (OT), two hours of PT (physical therapy) and two and three quarter hours of speech per week during this time with tasks being shaped to maximize success.
Results: Client improved in all functional domains. He developed ability to push himself up to standing with his more affected upper extremity and began to use manipulatives such as markers spontaneously.
Conclusion: Client had gains in fine motor control, dexterity, bilateral coordination and strength. He became for functional in daily life skills, becoming independent in self-dressing and toileting.

Key Words: constraint-induced movement therapy (CIMT), pediatric, upper extremity, function, cerebral palsy

Introduction

One of the most common causes of hemiparesis in children is due to prenatal, perinatal, or postnatal cerebrovascular accidents (CVA), commonly referred to as a stroke (Karmen, Maryles, Simpser & Berger-Gross, 2003). A stroke occurs when there is a vascular occlusion or hemorrhage, it can occur with an unknown etiology or secondary to sickle cell disease. A stroke can result in lesions that are the at the core of motor disorders during early stages of development (Karmen et.al., 2003). In some cases, this can result in a diagnosis of Cerebral Palsy (CP), which is diagnosed as decreased motor control and increased spasticity and is typically more significant in the upper extremity (Pellegrino, 2002). Children with hemiparesis may struggle to complete activities of daily living (ADL), participate in age appropriate play and conquer developmental milestones (Karmen et.al., 2003). Occupational therapists should be aware of how hemiparesis can also affect a child socio-emotionally as the ability to engage in age-typical behavior is compromised.

Standard care, which includes occupational and physical therapy has been demonstrated to have minimal effect in increasing the use of the more affected upper extremity (Mark, Taub & Morris, 2006). This is due to learned nonuse, which is normally permanent (Taub, Uswatte, Mark & Morris, 2006). Learned nonuse is when there is sufficient nerve innervation to functionally use a muscle group but the limb goes unused due to damage to the cerebral cortex, like from a CVA (Taub et.al., 2006).

Studies to treat learned non-use began many years ago. Nerves in the arms of monkeys were deafferented in order to simulate the ability a person has after experiencing a CVA. When monkeys were deafferented in-utero or immediately after birth, they were able to master all developmental milestones (i.e. rolling, crawling) with the exception of prehension and grasp. Controversially, if the limb was deafferented in older monkeys, there was an immediate loss of motor ability. This was treated with restraint and shaping activities and full use of the affected extremity became possible. This treatment was termed constraint induced movement therapy (CIMT) (Taub, Perrella, & Barro, 1973; Berman, Derasmo, Marti & Berman, 1978). Constraint therapy is now a widely accepted treatment for adult stroke patients, yet very few studies have examined constraint induced therapy in children (Wolf, Winstein, Miller, Thompson, Taub, Uswatte, & Morris et.al., 2008). It is thought that constraint therapy should be at least as good, if not more efficacious for children due to the neuroplasticity of the child's brain (Mark, 2006). Occupational therapists have explored the use of constraint induced movement therapy for children with decreased active arm movement and have reported a lot of success (Dickerson & Brown, 2007). Unfortunately, previous studies have not taken cost or availability into account. Previously, children have worn a cast for 21 consecutive days and received 6 hours of therapy daily which is not feasible in a typical treatment setting (Dickerson & Brown, 2007; Taub, Ramey, DeLuca & Echols, 2004). The present study looks to determine whether a shorter, more clinically feasible protocol with additional parent training can have similar results.

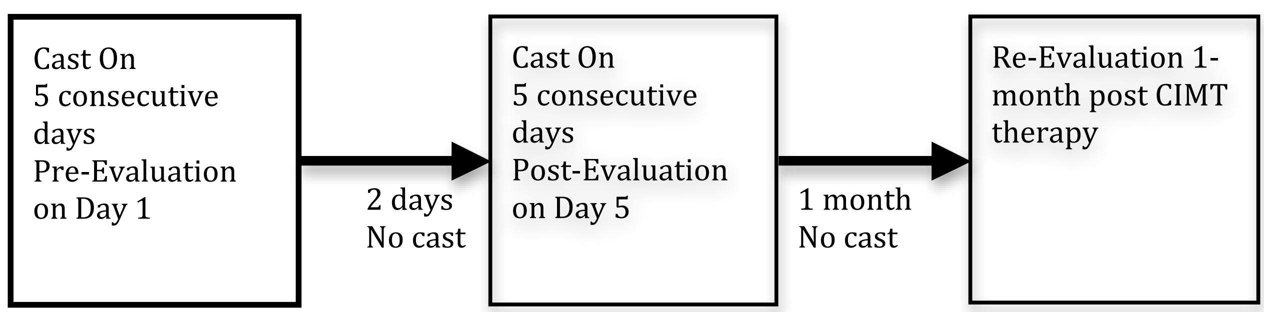
Methods

Design

This study was a repeated measures single-subject design intervention. The participant was casted for 10 complete days over a two-week period in June 2009. He was casted Monday to Friday and given the weekend between these two weeks to work on combining both hands into bilateral play. This design was elected because time constraints for both the family and therapists. Andrew's treating physician prescribed CIMT with at least six months between treatments. CIMT has not previously been done for such a short period, and for financial reasons, it is critical that it is determined what length of time is necessary to observe significant change. During the CIMT intervention period, the child received daily occupational therapy for 1-2 hours provided either by the child's therapist or a trained graduate student. He also received physical therapy for two hours weekly and speech therapy for an additional hour weekly. He had been seen by all three therapies prior to CIMT therapy.

INSERT FIGURE 1 HERE

Figure 1. Timeline of Treatment



A thirty-minute session was recorded of the client attempting to complete several family created goals prior to CI therapy and again on the last day prior to cast removal. Tasks analyzed were reach, grasp, sustained grasp, finger feeding, pinch, pull and dressing. Daily activities were chosen that would be motivating to the child and would encourage use of the left upper extremity. Activities included painting, bubbles, drawing, eating, and crawling. Additionally, the parent and the treating therapist completed The Child Arm Use Test and the Pediatric Motor Activity Log as adapted from Taub et.al. (2004).

INSERT TABLE 1 HERE

Table 1. Timeline of CI Therapy

	Monday	*Tuesday*	*Wednesday*	*Thursday*	*Friday*	*Total*
Week 1						
	Initial video OT and Casting SLP	OT PT SLP	OT SLP	OT PT SLP	OT-cast removed	OT~15 hours PT- 2 hours SLP- 2:45 hrs
Week 2						
	OT and Casting SLP	OT PT SLP	OT SLP	OT PT SLP	OT-cast removed	OT~ 15 hours PT- 2 hours SLP- 2:45 hrs
Week 3						
	OT PT (EOW) SLP	SLP	OT SLP	SLP	OT	OT- 3 hours PT-1 hr(EOW) SLP- 2:15 hrs

On any given week Andrew receives approximately three hours of occupational therapy and two hours and 15 minutes of speech therapy. He receives one hour of physical therapy every other week.

During CIMT treatment, Andrew received approximately 15 hours of occupational therapy per week (three hours per day), two hours of physical therapy and two hours 45 minutes of speech therapy.

Participant

The participant was a four-year-old white boy named Andrew (named changed to keep participant anonymous) who has CP and hemiparesis of his left upper extremity secondary to a prenatal cerebral vascular accident (CVA) of unknown cause. He was born full term without other medical complications. Andrew is from a affluent family consisting of the mother, grandmother and grandfather in a suburban community in North Carolina. Prior to CIMT therapy, Andrew presented with hypertonia in his left upper extremity. He had full passive range of motion, but could not reach full range actively, reaching maximum shoulder extension at about 80 degrees and maximum elbow extension at approximately 20 degrees. He presented with shoulder girdle retraction on the left side as well as significant flexion synergy patterns that inhibited his ability to grasp, reach or use his left upper extremity to aid in tasks. When a stimulus was presented to the subject on the left side, he would reach across his body with his right hand to reach the target or move his entire body to be able to access it with his right hand. However, if provided with sufficient time he was able to extend fingers to pick up a plastic ring. Andrew also presented with extreme preference for his right side in mobility. He rarely balanced weight between both sides of his body and generally preferred side lying on the right, and scooting on the right rather than crawling and used the right hand exclusively for climbing tasks. Andrew was always in a high guard position, with his arm in extreme flexion. This inhibited his ability to run and move through space comfortably. He was unable to perform bilateral tasks, which affected his ability to participate in many gross motor activities such as riding a bike and swinging on an adult swing (due to lack of grasp for holding on). Andrew was able to walk independently and was motivated and willing to participate in CIMT treatment.

Assessment

The Child Arm Use Test: This assessment was designed to use as a pre/post measure to analyze the amount of functional use a child has in an affected upper extremity. Fifteen items out of 21 were selected to evaluate the amount of participation, the quality of movement and the willingness to perform each action on a likert scale of 0-2, 0-5 and 0-3 respectively. (Taub, 2004). Actions assessed include important abilities to functionally play, such as removing puzzle pieces, striking a toy with a hammer, use markers and remove and throw a ball. Reliability and validity information is not available.

The Pediatric Motor Activity Log: This 22-item test evaluates how often and how well a child participates in specific actions necessary to complete activities of daily living; such as opening a door, pushing the body up with arm, eating finger foods and hold an item while sitting in a chair. It is scored using a 0-5 likert scale with 0.5 intervals that are individually defined. (Taub, 2004). Reliability and validity information is not available.

Procedure

Full parental and physician consent was obtained prior to beginning CI therapy. A fiberglass cast was molded onto the child's arm from the shoulder to the tips of his fingers. A sock was used to cover the cast in order to maintain cleanliness as well as prevent the child from using his fingers on his right hand. After five days, the cast was removed.

Pre-CIMT (A): Andrew was seen by the occupational therapist to ascertain if he had enough strength and range to be successful in CI therapy. He received OT treatment for 9 months to develop sufficient extension of digits in his left hand and sufficient strength in the left upper extremity. He was assessed for 30 minutes on the first day prior to casting. He was evaluated using goals derived by the family.

CIMT (B): Andrew's right arm was put in a fiberglass cast for ten days over a two-week period. The cast was worn 24 hours a day during this time. He received occupational therapy services daily for 1-2 hours and PT and speech services throughout the week.

No evaluation activities were used in treatment. Occupational therapy treatment focused on doing activities that were fun for Andrew including typical play activities as well as structured play with small manipulatives requiring use of the left hand.

Post-CIMT (A): After CIMT therapy, Andrew returned to his previous schedule of therapy and was encouraged by therapists and family members to use both hands in all tasks as he had been in months prior to casting. One month after the completion of CIMT therapy, Andrew was re-evaluated using the same criteria as before.

Results

Items that had the most improvement were with self-care, eating and playing. After CIMT, Andrew' scores increased exponentially, and attempted use of his affected limb about half of the time, although his movements were notably slower and not made with full effort. Of clinical value, Andrew improved from 1 to 4.5 on a 5 point Likert scale for his ability to push himself into a sitting position. Based on the results, Andrew performed at a higher level than he attempted activities, indicating that he continues to struggle with learned nonuse. The results suggest that he is able to perform at a higher function than he demonstrates. Despite this, it is clear that CIMT has had dramatic effects for Andrew's ability to participate in everyday activities. The parent reported a difference from 0 to 3 in his ability to scribble with a marker and from 0 to 4 on a scale of 5 for his ability to pick up a phone. His global rating scale improved from 1 to a 4 for his ability to use his more affected arm in an age typical manner. Andrew participated more in activities, going from a 0.36 to a 1.71 on a 2 point on the Child Arm Use Test and a 0.82 to a 3.09 on a 5 point scale on the Child Pediatric Motor Log, both showing significant improvement from the pre-CIMT phase. Andrew improved on his willingness to participate in activities using his more involved upper extremity from a mean of 0.79 to 2.36 on a scale of 3. He improved on his overall completion from a 0.79 to a 3 on a 5 point scale on the Child Arm Use Test and from a 0.70 to a 3.18 on a 5 point scale on the Child Pediatric Motor Log, which shows noteworthy correlational validity between the two assessments.

INSERT TABLES HERE

	How Often Mean	How Well Mean
Pre-CIMT	0.82	0.70
Post-CIMT	3.09	3.18

Table 2. Results from the Pediatric Motor Activity Log

	Participation	How Well	Willingness
Pre-CIMT	0.36	0.79	0.79
Post-CIMT	1.71	3.00	2.36

Table 3. Results from The Child Arm Use Test

INSERT FIGURE 1 and 2 HERE

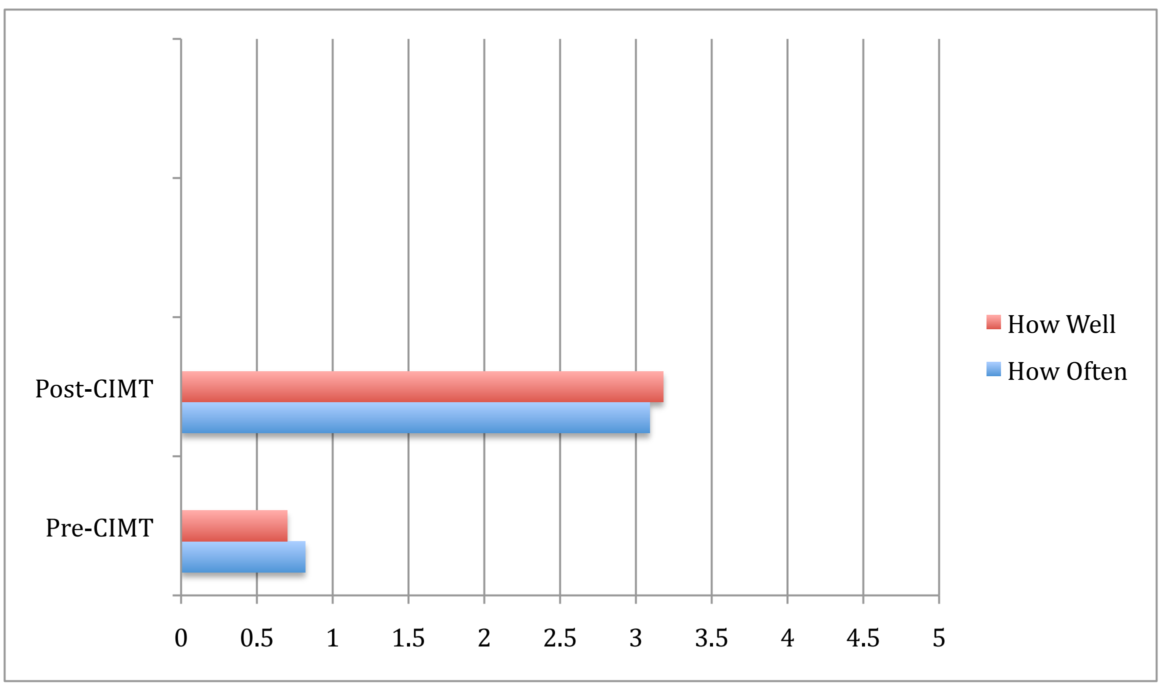


Figure 1. Results of Pediatric Motor Activity Log

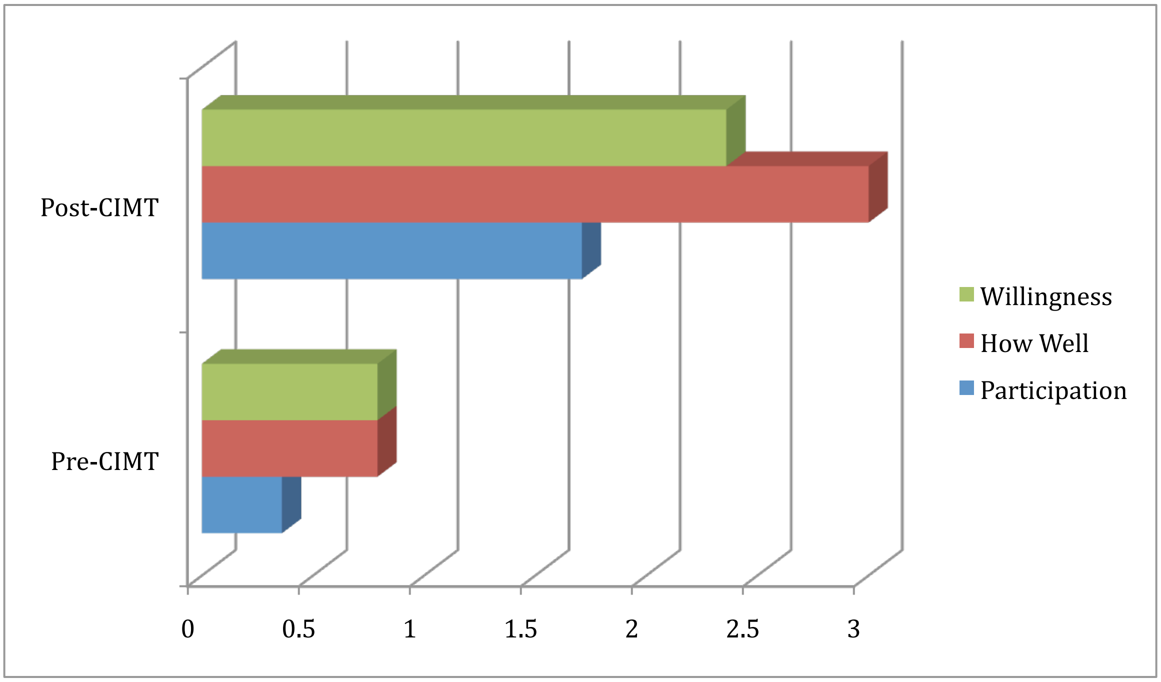


Figure 2. Results of the Child Arm Use Test

Discussion

These results are based on parent report. Parent report was chosen in order to obtain a more accurate and holistic perspective of Andrew's abilities in and out of the therapeutic environment. These results demonstrate that prior to CIMT treatment Andrew did not use his more affected upper extremity and attempts were not met with success. Functionally, Andrew improved significantly from constraint induced movement therapy. Therapists and caregivers were all pleased with the results. Prior to this study, Andrew had not used his left hand at all and performed all activities exclusively on his right side, including mobility. He did not crawl or climb using both legs interchangeably. Andrew has also been wearing an exo-muscular suit, TheraTogs, for the purpose of strengthening his postural muscles and increase functionality of gate and movement. This is not believed to have influenced the CIMT treatment for increased range or strength of the left upper extremity, but due to positioning of individual straps, may be a contributing factor for increased bilateral movements and decreased flexion synergy patterns.

Therapists who plan to use CIMT treatment should be cognizant that improvement may not be seen initially. In the first week, Andrew was reported to have significant trouble sleeping and refused to eat. When observed eating, he demonstrated regression in oral motor control, with decreased tongue lateralization and inability to move the bolus within the oral cavity. In the second week, these behaviors were minimized and improvements were seen. Andrew demonstrated the most success in the two weeks following CIMT.

His most noticeable improvements were in active range of motion; prior to CIMT he was able to flex his shoulder to only 60 degrees whereas after treatment he was able to actively flex his shoulder to nearly full range (140 degrees) which was evidenced through his ability to reach and grab for objects. He went from having minimal functional range in his left upper extremity to being able to reach across a table, grab small items such as food or beads and climb typical playground equipment. He also had gains in functional grasp, by the end of CI therapy he was able to grasp a paintbrush and marker and scribble. On several occasions, he was also able to imitate letters for his name indicating significant improvement in manual dexterity and motor control.

The difference in the amount of associated movements of the non-involved extremity pre and post treatment was noteworthy. Prior to therapy, Andrew was unable to complete movements using his left upper extremity without using his right hand simultaneously. Upon study completion, there was no visible movement of his non-affected extremity. This indicates that new neuro-motor patterns have been developed.

Furthermore, flexion patterns were significantly reduced. Andrew was able to run with both of his arms at his sides with appropriate movements. This makes movement and play much more adaptive and functional with less risk for injury.

Perhaps the most motivating element of this study was the pleasure and satisfaction that both the child and parent had during and after therapy. Andrew discovered new ways to play, interact and move his body. Improvements in psychosocial aspects of his life were documented, as he appeared to have increased self-confidence on the playground and interacting with peers. Andrew developed dressing skills, feeding skills and play skills that are essential for his ability to develop a sense of autonomy and independence. He also improved in areas such as bilateral control and balance, which are also critical to his development in age appropriate motor goals.

Assessments were chosen in order to help discriminate between his motor ability and how much he was actually using his affected upper extremity. The authors also believe that that shaping activities is necessary in order to maintain the clients enthusiasm, provide motivation and small victories so that the client is able to recognize progress. On the same token, when working with children, it is also necessary to provide positive reinforcement through feedback and verbal encouragement. Furthermore, it would be remiss to not mention the effort made on the behalf of Andrew's caregivers who provided constant support and elaborated on treatment after therapy was over. CIMT may not be as effective without such a strong home program.

While constraint induced movement therapy was a huge success for Andrew, he still struggles with wrist extension and supination of his affected forearm. He is unable to control the release of an object in supination. This makes it difficult for Andrew to weight bear on his affected side that can complicate future development.

In conclusion, CIMT treatment facilitated effective change in a child with left hemiplegic cerebral palsy. It is worth mentioning that left sided hemiplegia tends to be more significant than hemiplegia that affects the right side. However, as this was a single case study this data may not be generalized to the larger public and would be difficult to replicate precisely. More investigation needs to be done in order to determine the most feasible and effective treatment protocol for clinicians to use. Previous research has not identified benefits or detriments of using a 24-hour casting protocol, future research should identify best practice for casting in CIMT therapy.

Appendix: The Child Arm Use Test

Adapted from:
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,* 305-312.

Hand Used: Right/Left	Participation	How Well	Willingness
1. Strike a toy with hammer	___	___	___
2. Use markers for scribbling	___	___	___
3. Pick up snack	___	___	___
4. Pull lever	___	___	___
5. Push button	___	___	___
6. Turn knob	___	___	___
7. Push top	___	___	___
8. Remove puzzle pieces with large knob	___	___	___
9. Remove puzzle pieces with small knob	___	___	___
10. Squeeze horn	___	___	___
11. Remove ball	___	___	___
12. Place or throw ball	___	___	___
13. Remove phone (vertically)	___	___	___
14. Remove phone (horizontal)	___	___	___
15. Release clothes pin	___	___	___

Global Rating:_________

Appendix: The Pediatric Motor Activity Log

Adapted from:
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,* 305-312.

	How Often	**How Well**
1. Hold a bottle/cup	___	___
2. Pick up and hold a small item while sitting in a chair	___	___
3. Pick up and hold a large item while sitting in a chair	___	___
4. Eat finger foods	___	___
5. Pick up an object out of arms reach	___	___
6. Push a button	___	___
7. Open a door or cabinet	___	___
8. Use arm to move across floor	___	___
9. Take off shoes or socks	___	___
10. Pull a toy with a string	___	___
11. Turn a knob	___	___
12. Pick up a cylindrical object (i.e.crayon)	___	___
13. Throw a ball or similar object	___	___
14. Hold a handle on riding, pulling, or push toy	___	___
15. Push up front of body with weaker arm while on stomach	___	___
16. Hold an item while in standing position	___	___
17. Carry an item from place to place	___	___
18.Stop or roll a ball	___	___
19. Pop bubbles	___	___
20. Push into sitting position	___	___
21. Reach to be picked up by a parent	___	___
22. Push arm through sleeve of clothing	___	___

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References

Berman, D., Derasmo, M.J., Marti, A. & Berman A.J. (1978). Unilateral forelimb deafferentiation in the monkey: purposive movement. *Journal of Medical Primatology, 7*(2), 106-113.

Brady, K. & Garcia, T. (2009). Constraint-induced movement therapy (CIMT): pediatric application. *Developmental Disabilities, 15,* 102-111.

Dickerson, A.E. & Brown, L.E. (2007). Pediatric constraint-induced movement therapy in a young child with minimal active arm movement. *American Journal of Occupational Therapy, 61,* 563-573.

Karman, N., Maryles, J., Baker, R.W., Simpser, E., & Berger-Gross, P. (2003). Constraint-induced movement therapy for hemiplegic children with acquired brain injuries. *Journal of Head Trauma Rehabilitation, 18*(3), 259-267.

Mark, V.W., Taub, E., & Morris, D.M. (2006). Neuroplasticity and constraint induced movement therapy. *Europa Medicophysica, 42*(3), 269-284.

Martin, A., Burtner, P.A., Poole, J., & Phillips, J. (2008). Case Report: ICF-level changes in a preschooler after constraint-induced movement therapy. *American Journal of Occupational Therapy, 62*(3), 282-287.

Pellegrino, L. (2002). Cerebral palsy. In M.L. Batshaw (Ed.), *Children with disabilities* (5th ed., pp.499-528) Baltimore: Paul H. Brooks.

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,* e1111-e1122.

Stearns, G.E., Burtner, P., Keenan, K.M., Qualls, C. & Phillips, J. (2009). Effects of constraint-induced movement therapy on hand skills and muscle recruitment of children with spastic hemiplegia cerebral palsy. *Neurorehabilitation, 24,* 95-108.

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,* 305-312.

Taub, E., Uswatte, G., Mark, W.W. & Morris, D.M. (2006). The learned nonuse phenomenon: implication for rehabilitation. *Europa Medicophysica, 42*(3), 241-255.

Taub, E., Griffin, A., Nick, J., Gammons, K., Uswatte, G. & Law, C.R. (2007). Pediatric CI therapy for stroke-induced hemiparesis in young children. *Developmental Neurorehabilitation, 10*(1), 3-18.

Taub, E., Perrella, P. & Barro, G. (1973). Behavioral development after forelimb deafferentation on day of birth in monkeys with and without blinding. *Science, 181*(103), 959-960.

Wolf, S.L., Winstein, C.J., Miller, J.P., Thompson, P.A., Taub, E. Uswatte, G., Morris, D., Blanton, S., Nichols-Larson, D., & Clark, P.C. (2008). Retention of upper limb function in stroke survivors who have received constraint-induced movement therapy: the EXCITE randomized trial. *Lancet Neurology, 7*, 33-40.