Modified Constraint-Induced Movement Therapy in a Day Camp for Children with Spastic Hemiplegic Cerebral Palsy: Intervention Effects and Consideration of Personal Factors

By

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EFFECTS OF CONSTRAINT-INDUCED MOVEMENT THERAPY IN CHILDREN AGED 5-9 YEARS WITH SPASTIC HEMIPLEGIC CEREBRAL PALSY

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ABSTRACT

Constraint-induced movement therapy (CIMT) has been demonstrated to yield functional improvements for children with spastic hemiplegic cerebral palsy (CP); however, many studies have reported inconsistent findings with regards to the extent of the benefits observed following the intervention. This study sought to examine the effects of CIMT in the context of a day camp in this population; it also examined the child-therapist (C-T) interaction during the assessment sessions as a potential factor influencing the child's scores on tests of motor performance. This interaction has not yet been formally measured in the literature, and may influence the perceived outcomes of CIMT. ***Motor Outcomes:*** Results demonstrated significant improvements in quality of use of the upper extremity following the intervention; the improvements were maintained at the 3-month follow-up. Analysis of each individual participant yielded additional information on clinically significant improvements. ***C-T Outcomes:*** Results demonstrated that the strength of the C-T interaction was significantly and positively correlated with the scores obtained by participants on motor assessments. The results of this study indicate that modified CIMT is effective in inducing lasting and meaningful changes in children with spastic hemiplegic CP. They also suggest that the C-T interaction may contribute to a participant's performance during the assessment session, which may ultimately affect the perceived outcomes of CIMT.

Keywords: spastic hemiplegic cerebral palsy, constraint-induced movement therapy, child-therapist alliance, child-therapist interaction, motor intervention

STATEMENT OF ORIGINALITY

I, Ashley M. E. Thompson, hereby declare that this thesis is, to the best of my knowledge, original, except as acknowledged in the text. I further declare that the material contained in this thesis has not been previously submitted, either in whole or in part, for a degree at this or any other university.

CO-AUTHORSHIP STATEMENT

The following individuals contributed to the work: Serena Chow and Cathy Vey, Occupational Therapists at Grandview Children's Centre. Serena and Cathy were extensively involved in the organization of Cast Camp. In addition, they collaborated with Dr. Meghann Lloyd and I on such things as recruitment efforts, motor assessments to be used, and the planning of the parent training session on how to effectively promote two-handed activities at home (Serena directed this session). Finally, they provided valuable feedback on the manuscripts contained within this thesis.

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LIST OF ABBREVIATIONS USED

CP	Cerebral palsy
C-T	Child-Therapist
CIMT	Constraint-induced movement therapy
CTC	Children’s Treatment Centre
fMRI	functional Magnetic Resonance Imaging
GMFCS	Gross Motor Function Classification System
ICF	International Classification of Functioning, Disability and Health
MACS	Manual Ability Classification System
NDT	Neurodevelopmental Therapy
OT	Occupational Therapist
PEDI	Pediatric Evaluation of Disability Inventory
PT	Physical Therapist
QUEST	Quality of Upper Extremity Skills Test
SD	Standard Deviation
TPOCS-A	Therapy Process Observational Coding System – Alliance
WHO	World Health Organization

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SECTION 1: INTRODUCTION

INTRODUCTION TO THESIS

Cerebral Palsy

Cerebral palsy (CP) refers to a group of movement and posture disorders caused by a non-progressive but permanent abnormality in the fetal or infant brain (Bax, Tydeman, & Flodmark, 2006). The majority of cases of CP result from the incidence of a lesion or malformation during prenatal development, labour, or early in post-natal development (Azzopardi et al., 1999; Cowan et al., 2003). In children with neonatal infarction (perinatal stroke), the majority of infarcts appear to involve one or more branches of the middle cerebral artery (Azzopardi et al., 1999; Cowan et al., 2003); injury to subcortical regions such as the basal ganglia, the cortex, and the thalamus are also common (Cowan et al., 2003). Although newer imaging techniques are often useful in aiding clinicians to localize the origin(s) of the pathology in CP, the causes of perinatal encephalopathy such as that seen in CP remain poorly understood (Cowan et al., 2003). CP occurs on average in 1 out of 500 children, making the study of the disorder as well as its treatment both relevant and important (Blair & Watson, 2006). The prevalence of CP has remained relatively stable over the past 20 years, indicating that CP is a persistent disorder that will predictably continue to be the most common paediatric physical disability in the coming years (Stanley, Blair, & Alberman, 2000; Reid, Carlin & Reddihough, 2011). CP is commonly associated with a variety of additional impairments, including intellectual disabilities, epilepsy, learning disabilities, and sensory impairments (Odding, Roebroeck, & Stam, 2006; Prasad, Verma, Srivastava, Das, & Mishra, 2011).

The most common form of CP is spastic hemiplegic CP, which is characterized by rigid movements as well as asymmetric motor impairment, and affects approximately one third of individuals diagnosed with CP (Hagberg, Hagberg, Beckung, & Uvebrant, 2001; Platt et al., 2007; Reid et al., 2011). In hemiplegia, one side of the body is more impaired than the other; the upper limb is typically more affected than the lower limb, and the impairments compromise the child's ability to reach, grasp, release and manipulate objects (Sakzewski, Ziviani & Boyd, 2009). Limited strength and coordination on one side of the body affect many aspects of the child's life, including play, self-care, and overall function in many daily activities, thus interfering with proper motor development on multiple levels (Brady & Garcia, 2009).

Therapies for CP and Constraint-Induced Movement Therapy

The most commonly employed movement therapies for treating individuals with CP are delivered by physical therapists (PTs) and occupational therapists (OTs), and include such therapies as neurodevelopmental therapy (NDT; Boyd, Morris, & Graham, 2001). Effective treatment methods for the upper limb impairment observed in CP are needed; constraint-induced movement therapy (CIMT) is a relatively new motor intervention that began gaining attention as a potential therapy for children with CP more than a decade ago (Boyd et al., 2001). CIMT is a form of rehabilitative therapy that involves constraining the less affected limb, while simultaneously training the more affected limb (Taub & Crago, 1998). The technique was developed by Edward Taub (1980) based on work that was performed using deafferented monkeys (Knapp, Taub, & Berman, 1963). Knapp and colleagues conditioned monkeys to avoid a shock by flexing one of their forelimbs in response to an auditory stimulus; the authors then deafferented the sensory nerves of the conditioned forelimbs, and found that the monkeys were able to be re-trained to elicit the avoidance response in the conditioning situation (Knapp et al., 1963). CIMT was first introduced to the human population in an attempt to treat the hemiparesis observed following stroke in adults; functional improvements were observed consistently following CIMT in this population (Wolf, Lecraw, Barton & Jann, 1989; Morris, Crago, DeLuca, Pidikiti & Taub, 1997; Kunkel et al., 1999).

CIMT in Children with CP

CIMT is now commonly used in children with CP (Hoare, Imms, Carey, & Wasiak, 2007); in this population, however, the therapeutic outcomes published in the literature have varied. While some studies have yielded positive outcomes for all participants who receive CIMT (Taub, Ramey, DeLuca, & Echols, 2004; Bonnier, Eliasson & Krumlinde-Sundholm, 2006; DeLuca, Echols, Law, & Ramey, 2006; Al-Oraibi & Eliasson, 2011), others have yielded positive outcomes for only some participants (Charles, Lavinder, & Gordon, 2001; Cope et al., 2010; Eliasson, Shaw, Berg, & Krumlinde-Sundholm, 2011), and still others have found positive results on only some measures (Aarts, Jongerius, Geerdink, van Limbeek & Geurts, 2010; Aarts, Jongerius, Geerdink, van Limbeek, & Geurts, 2011; Chen et al., 2012). While many studies have shown that CIMT is effective in improving the function of the more affected limb in this population (Hoare et al., 2007; Wolf, 2007; Huang et al., 2009), more research is needed to confirm the most effective way of implementing the intervention in order to maximize the therapeutic benefits for participants. One area of research that has begun to address this question involves the investigation of the optimal setting in which to administer CIMT.

Several studies have yielded successful results when employing modified forms of CIMT in alternative settings, such as at home, at school, and in community settings, such as during a day camp (Bonnier et al., 2006; Aarts et al., 2010; Cope et al., 2010; Taub et al., 2011). More research into the possibility of successfully employing CIMT in alternative settings is needed, as the originally proposed guidelines for clinic-based CIMT interventions require 60-84 hours of physical therapy per week, making it a costly intervention, both financially as well as in terms of therapists' time. In addition, many researchers are beginning to acknowledge the importance of transferring skills learned during therapy into daily life (Naylor & Bower, 2005; Chen et al., 2012; Hsin et al., 2012; Rostami & Malamiri, 2012); implementing a motor intervention in a more natural setting would likely facilitate this transfer of acquired skills into everyday functioning. CIMT demonstrates promise as a feasible activity-based intervention; more research is needed to support its use in alternative settings.

Regardless of the intervention's setting, motor interventions for CP are based in the knowledge that the human brain has the capacity to reorganize itself by forming and maintaining new connections (Nudo, Wise, SiFuentes, Milliken, & Garrett, 1996; Levin, 2003; Schaechter, 2004). The formation of these new connections is activity-dependent and is termed neuroplasticity; specifically, cortical reorganization refers to the reorganization of somatosensory cortical maps whereby areas responsible for other body parts begin to elicit responses for areas that previously had little or no response (Pons et al., 1991). Cortical reorganization has been shown to occur following rehabilitation in both animal models of CP (Biernaskie & Corbett, 2001; Maier et al., 2008) and in children with CP (You et al., 2005; Cope et al., 2010). Neuroplasticity has been consistently demonstrated to be effective in the developing brain in both animals (Martin, Chakrabarty, & Friel, 2011) and humans (Sutcliffe, Gaetz, Logan, Cheyne, & Fehlings, 2007), thus it follows that children may benefit most from an intervention aimed to induce cortical reorganization. CIMT has the ultimate goal of inducing such neuroplasticity, and several studies have begun incorporating neuroimaging techniques such as functional Magnetic Resonance Imaging (fMRI) into their research in order to investigate the possible neuroplastic effects of CIMT (Cope et al., 2010; Sutcliffe et al., 2007; Walther et al., 2009). Investigation into any cortical changes that may occur following CIMT will assist researchers in better understanding the effects of CIMT. In addition, imaging studies may elucidate the importance of certain personal factors that may affect the outcome of CIMT, such as age and level of impairment; this may inform the planning and implementation of future CIMT interventions. One personal factor that may influence the perceived outcome of CIMT is the interaction that occurs between the child and the therapist who is administering the motor assessments. This factor is measurable within the scope of a motor intervention, and as such, was analyzed in the current study in order to determine its potential influence on the perceived outcomes of CIMT in this population.

Therapeutic Alliance Importance for Therapeutic Outcome

Therapeutic alliance is a concept that dates back to the work of Anna Freud; more than 60 years ago, Freud acknowledged that an “affectionate attachment” between the child and therapist was a “prerequisite for all later work” in child therapy (Freud, 1946, p. 31). Research in the area of adult therapist alliance has demonstrated that alliance is a consistent predictor of successful therapy outcomes (Horvath & Symonds, 1991). This is presumably because a productive relationship between the therapist and the client fosters an understanding of the reasons for the intervention; it may also motivate the client to perform the required tasks during the therapy in order to experience a successful outcome from the treatment. If the client trusts the therapist, which is paramount in a beneficial therapeutic relationship, then he or she is more likely to believe that the rehabilitative procedures merit effort and commitment. Although the client-therapist interaction has been studied extensively in the adult population, the relationship between the child and the therapist has only recently begun to be investigated in the context of scientific research (Shirk, Karver, & Brown, 2011). It has been noted that the link between the child-therapist (C-T) alliance and treatment outcome is inconclusive; for this reason, research in this area is needed (McLeod & Weisz, 2005).

Alliance in Child Therapy

Because children are often in therapy as a result of the parent/guardian's understanding of its benefits, and may lack the cognitive capabilities to understand these concepts in the same way that adults do, the situation involving the child's alliance with the therapist must be examined under different pretenses (McLeod & Weisz, 2005). Specifically, certain developmental considerations are important to take into account when children are the clients of a rehabilitative intervention. McLeod and Weisz (2005) discuss the two components of the interaction that are particularly important in the C-T alliance: bond, which refers to the affective aspects of the relationship (i.e. temperament, feelings, and attitudes), and task, which refers to participation in the therapeutic activities.

The therapist's ability to develop a warm 'bond' and engage the child in the therapeutic process (task) is believed to be crucial to the success of the therapy (McLeod

& Weisz, 2005). However, children may develop a relationship with the therapist for a number of reasons; for example, the child may feel a certain need being fulfilled by the therapist that is not fulfilled elsewhere: “If no one at home plays games with the child, for example, he might like to come to treatment because there a grown-up pays attention to him” (Freud, 1946, p.31). As such, the relationship between a child and a therapist may not be as cognitively consensual as the relationship between an adult and a therapist, due to the child’s limitations in comprehension of the therapy’s purpose. Similarly, difficulties exist in the ‘task’ area of the alliance, which refers to how the therapist engages the child in therapeutic activities; whereas adults and their therapists can agree upon certain goals and expected outcomes, children may not be able to link therapeutic activities with desired outcomes (McLeod & Weisz, 2005). These factors may affect the effort that children put forth in therapy sessions, and may also affect their motivation to do ‘homework’ between sessions, both of which would have an effect on the results of a motor intervention in children with CP.

Conclusion

Effective motor interventions for children with spastic hemiplegic CP are needed; CIMT has been implemented in many studies, and has demonstrated that it has the potential to induce lasting functional benefits for individuals in this population. More research is needed in this area to support the use of CIMT in settings outside of the clinic; research supporting the effectiveness of CIMT in alternative settings will provide evidence for a more economically sustainable and child-friendly form of movement therapy for children with hemiplegic CP. Secondly, researchers should begin to investigate the individual factors which may influence the outcomes of CIMT, as several studies have noted their importance within this population (Hoare et al., 2007; Wolf, 2007; Huang et al., 2009; Cope et al., 2010; Wang et al., 2013). This study will be the first to formally investigate the C-T interaction as a possible factor contributing to the perceived outcomes of the therapy. A greater understanding of the most effective ways to promote the use of the affected limb using CIMT, in conjunction with a more complete understanding of the personal and environmental factors which influence the therapeutic outcome, will ultimately assist interventionists in effectively treating the upper-limb impairment that is observed in children with spastic hemiplegic CP.

LITERATURE REVIEW

Part I: Constraint-Induced Movement Therapy

Using Constraint-Induced Movement Therapy in Children

CIMT is a therapeutic technique that consists of two main components: restraint of the less-affected limb, and simultaneous practice of the more affected limb (Taub et al., 1994). The originally proposed recommendations for employing CIMT as a therapeutic technique were to restrain the less-affected limb for 90% of the individual's waking hours, and to perform intensive movement therapy for 6 hours per day over a two-week period (Taub, Crago, & Uswatte, 1998). In the population of children with hemiplegic CP, however, researchers must contend with unique challenges; the intensity of the traditional CIMT therapy may be too great to retain the attention of young children (Brown, Rensburg, Lakie, & Wrigh, 2008; Gilmore, Ziviani, Sakzewski, Shields, & Boyd, 2010). The therapy should ideally include a variety of child-geared activities as well as intermittent breaks in order to maximize compliance (Bonnier et al., 2006; Brown et al., 2008; Aarts et al., 2010; Cope et al., 2010; Gilmore et al., 2010). Further, it has been demonstrated that testing compliance is a strong predictor of improvement following CIMT (Charles, Wolf, Schneider, & Gordon, 2006); children are often enrolled in therapy by their caregivers, and may not understand that performing their best during an intensive training session will yield the most beneficial results. As such, researchers have been challenged to cater CIMT to the pediatric population; many researchers choose to alter the therapeutic activities to ensure that they are age-appropriate, while others opt to decrease the duration of the therapy. Many studies also reduce the number of hours of affected-limb restraint, such that children are only wearing the restraining device during CIMT sessions.

CIMT in Children with CP: Evidence of Motor and Functional Improvement

Many studies have tested the efficacy of CIMT in children with hemiplegic CP; these studies have used a variety of methodologies, including differences in therapeutic setting, duration of CIMT, and activities performed during the intervention. Many positive findings have emerged from the studies conducted, suggesting that CIMT has the ability to induce lasting functional improvements in children with spastic hemiplegic CP.

Studies in Clinical Settings

DeLuca et al. (2006) conducted a study aimed at testing the efficacy of CIMT in a randomized, controlled, crossover trial. The authors recruited 18 participants, ranging from 7-96 months of age (mean age = 3 years, 6 months); CIMT was administered for 6 hours per day for 21 consecutive days. In this study, the children wore a bi-valved cast for the duration of the experiment (24 hours per day), removing it only once each week to check for any problems (DeLuca et al., 2006). The authors reported significant motor improvement as indicated by standardized motor assessments at the post-intervention assessment; these improvements were maintained at the 3-week follow-up (DeLuca et al., 2006). As expected, individuals in the control group did not experience a similar improvement; however, once they were crossed over and received CIMT, they similarly experienced a significant improvement in motor function (DeLuca et al., 2006).

Taub et al. (2004) used a similar cohort in their trial to test the efficacy of CIMT in children with hemiplegia, using 18 children with hemiplegic CP ranging in age from 7-96 months. Unlike DeLuca et al. (2006), Taub et al. (2004) tested the effects of the intervention at a 3-month as well as a 6-month follow-up session. The children were randomly assigned to one of two groups, either the test group or the control group. The test group received modified CIMT, described as a modified version of the CIMT used in adult stroke patients, for 6 hours per day for 21 consecutive days. The less-affected upper limb was casted from upper-arm to fingertips in the test group; the CIMT consisted of interesting and useful activities as well as everyday tasks, and praise and rewards were offered upon successful completion of tasks. Tasks such as reaching, grasping, object manipulation and weight bearing on the arm were first divided into their individual component skills and practiced; these tasks were then combined to comprise a target activity. When a new movement skill was demonstrated, the therapist proceeded to shape this skill by increasing the demands for precision, strength and fluency of the movement. The control group received ‘Conventional Therapy’, an alternative form of movement therapy delivered by either a PT or an OT for a mean of 2.2 hours per week for the duration of the experiment.

Taub et al. (2004) reported statistically significant results on all assessment measures at each assessment time; improvements were reported for the CIMT group on all measures. Post-assessments were done immediately following the intervention, 3 weeks following the intervention, and at 3 and 6 months following the intervention. The authors found that children in the intervention group showed a mean of 9.3 new motor patterns following CIMT as measured by the Emerging Behaviors Scale, while the usual care group acquired only 2.2 new motor patterns on average (Taub et al., 2004). The authors also reported an increase in the amount and quality of use of the affected limb in the CIMT group, as well as significant between-group differences in the amount and quality of use of the affected limb. They further reported positive subjective feedback from the parents of the participants, who stated that their children demonstrated increased self-confidence, increased interaction with their environment, and new sensory awareness of their affected limb.

Charles et al. (2006) performed CIMT in 22 children aged 4.5-9 years (mean age = 6 years, 8 months) with spastic hemiplegic CP; the study was a randomized controlled trial with a delayed treatment option for children initially randomized to the control group. In this study, an arm sling was worn for 6 hours per day for 10 out of 12 consecutive days; children were engaged in play and other functional activities in a clinical setting. In addition, a home exercise program was established wherein parents were instructed to have the children practice using the affected limb without restraint at home for 1 hour per day during the two-week trial; the home practice time was increased to 2 hours per day for 6 months following the intervention (Charles et al., 2006). The treatment group demonstrated improved movement efficiency and dexterity of the affected upper extremity that was maintained at the 6-month follow-up; no significant changes were observed on measures of strength, sensibility (measured with two-point discrimination), or muscle tone. It was found that the crossover group did not experience similar benefits from the CIMT intervention; the authors suggested that the group's experience in the laboratory setting may have hindered their motivation following the usual care treatment (Charles et al., 2006). Another study was performed in the same lab using a similar methodology (Gordon, Charles, & Wolf, 2006); the authors combined a clinic-based CIMT intervention with a home exercise program for 12 children aged 4-8 years (mean age = 6 years, 8 months) with a diagnosis of spastic hemiplegic CP. The structure of the CIMT intervention was the same as that of Charles et al. (2006); it was found that children demonstrated improved performance on standardized tests of motor function following CIMT, and that these improvements were maintained at the 6-month follow up. In addition, caregivers reported increased frequency of use and improved quality of use of the affected limb following the intervention (Charles et al., 2006). Naylor & Bower (2005) also employed a modified CIMT intervention in conjunction with a home exercise program to test the effects of CIMT in children with hemiplegic CP. Their intervention involved 9 children aged 2-5 years; the children attended a clinic for 1 hour twice weekly, for a total of 12 weeks. A home exercise program was developed for implementation on non-treatment days, which lasted for the duration of the 12 week trial. During the 1-hour therapy sessions, only gentle restraint (i.e. an adult holding the child's unaffected arm during structured activities) and verbal encouragement to 'use the other hand' were used (Naylor & Bower, 2005). Improvements were observed on standardized tests of motor performance that persisted at the 6-month follow-up, indicating that a less intense model of CIMT can induce lasting functional benefits for children with hemiplegic CP.

More recently, one study specifically attempted to determine the effects of the environment on the outcome of CIMT interventions (Rostami & Malamiri, 2012). The authors investigated the effects of modified CIMT in 14 children aged 4-8.5 years (mean age = 6 years, 2 months); their primary objective was to determine if a home-based intervention would be more beneficial than a clinic-based intervention for children with hemiplegic CP (Rostami & Malamiri, 2012). Children were randomized into either a home-based CIMT group or a clinic-based intervention; the restraining splint was worn by all participants for the majority of waking hours, being removed only for bathing and short periods of rest for both groups. Though the restraint was worn nearly full-time throughout the intervention, modified CIMT was only administered for 1.5 hours, 3 times per week, for a total of 10 sessions. It was found that both groups improved following the intervention; however, only the home group showed continued improvement at the 3-month follow-up session on all measures. Overall, the home group's improvement was better than that of the clinic group, and the authors suggested that the application of CIMT in natural settings should be investigated further (Rostami & Malamiri, 2012).

The studies performed in a clinical setting have used wide age ranges and a variety of intervening techniques; these studies have consistently demonstrated that CIMT is effective in inducing lasting functional improvements in children with spastic hemiplegic CP. It appears that the importance of transferring the shaping and practice of the unaffected limb to more natural settings is gaining attention in the field, as an increasing number of studies appear to be implementing home exercise programs and/or deliberately performing the interventions in settings outside of the laboratory.

Studies in Alternative Settings

Several studies have opted to perform the CIMT intervention in an alternative setting; such settings include the home, day camps, and some combinations of clinical and community settings. Al-Oraibi & Eliasson (2011) performed a randomized controlled trial using a home-based model to compare CIMT and NDT in 14 children with spastic hemiplegic CP aged 2-9 years (mean age = 3 years, 11 months). The intervention was 8 weeks in length, and CIMT was administered by caregivers for 2 hours per day, 6 days per week; the NDT group had 1-2 hours of therapy per week. Standardized tests of motor performance were administered before the intervention, immediately following the intervention, and 2.5 months following the intervention's end (Al-Oraibi & Eliasson, 2011). At the post-assessment session, it was found that the NDT group showed almost no improvements; the CIMT group improved significantly more than the NDT group on all measures, and the observed improvements persisted at the 2.5 month follow-up. Another group of authors studied the effects of CIMT in a 4-year old child with hemiplegic CP using a home-based model (Brekke, Ehler, Furze, & Goulet, 2004). The unaffected limb was restrained for an average of 2.5 hours a day, for a total of 4 weeks; standardized motor assessments were performed prior to, immediately following, and 3 months following the intervention. In this model, caregivers administered CIMT at home and encouraged practice of the affected limb on a daily basis (Brekke et al., 2004). Following the intervention, marked improvements were observed in the child's functional ability to use the affected limb. The results of the studies by Al-Oraibi & Eliasson (2011) and Brekke et al. (2004) demonstrate the usefulness of CIMT in a home-based setting, even with small sample sizes (and one single subject design); the authors suggest that CIMT can be implemented in various environments with very few extra costs for families and health organizations.

Several randomized controlled trials with larger sample sizes have also been performed in a home setting; Chen et al. (2012) performed one such CIMT intervention. Participants were 47 children aged 6-12 years with spastic hemiplegic CP (mean age = 8 years, 9 months); 24 children were assigned to the CIMT group, and 23 children were assigned to the usual care group. The intervention lasted 4 weeks, and involved individualized therapist-based training at home for 3.5-4 hours per day, 2 days per week

(Chen et al., 2012). It was found that the CIMT group improved more than the usual care group on the grasping sub-sections of the tests of motor performance; the CIMT group also improved more in hand use and quality of hand use (Chen et al., 2012). Finally, the CIMT group improved more than the usual care group on some, but not all, aspects of reaching control (Chen et al., 2012). Hsin et al. (2012) also performed a randomized controlled trial using CIMT in a home-based intervention for 22 children aged 6-8 years with spastic hemiplegic CP (mean age = 6 years, 11 months). CIMT was administered for 3.5-4 hours per day, twice weekly for 4 weeks; assessments were performed pre, post, and 3 months following the intervention (Hsin et al., 2012). The CIMT group improved more on standardized tests of motor performance when compared to the usual care group at the post-assessment and at the 3-month follow-up. The CIMT group also demonstrated greater improvements in the amount of use and quality of use of the affected limb; these improvements persisted at the 3-month follow-up assessment (Hsin et al., 2012). Finally, the CIMT group improved more on domains of lasting well-being and social acceptance, emotional well-being and self-esteem when compared to the usual care group. Lin et al. (2011) performed a randomized controlled trial using CIMT in a home-based model for 21 children aged 4-10 years (mean age = 6 years, 7 months) with a diagnosis of spastic hemiplegic CP; a dose-matched usual care intervention that also took place in the home with a PT was administered to the control group (the usual care intervention was based on NDT). The interventions were administered for 3.5-4 hours per day, twice weekly for 4 weeks; during the interventions, both groups were restrained, such that the only difference between the groups was the actual therapy administered. Assessments were performed pre, post, and 6 months following the intervention. Children in the CIMT group demonstrated greater improvements when compared to the usual care group on nearly all tests of motor performance; many of these improvements persisted at the 6-month follow-up, demonstrating the effectiveness of CIMT over NDT in a home-based model for children with hemiplegic CP.

Cope et al. (2010) tested the effects of CIMT in 10 children between the ages of 7 and 14 (mean age = 11 years, 0 months); the therapy was administered for 4 hours per day for 2 weeks of weekdays only. In order to make the therapy relevant for daily functioning, activities were performed in a variety of settings, including in the clinic, on the playground, and in the participants' homes (Cope et al., 2010). The authors reported that some, but not all, children showed improvement following CIMT; those who showed the greatest gains were the three children who were classified with moderate impairments in the affected arm (Cope et al., 2010). Further investigation with fMRI revealed that two children displayed enhanced fMRI signalling following CIMT; these children were two of the three who experienced significant motor gains (Cope et al., 2010). The incidence of enhanced fMRI signalling suggests that cortical reorganization, and/or an alteration in neuron firing promoting movement in the affected arm, occurred in the brains of these individuals as a result of CIMT (Cope et al., 2010). Another important finding was that the children with the highest levels of impairment did not benefit the most from CIMT; the results demonstrated that significant gains were only observed in children with moderate impairment, indicating a non-linear relationship between the benefits of CIMT and degree of motor impairment. Whereas the children with the highest amount of impairment may have extensive sensorimotor damage that inhibits their ability to improve from a therapy such as CIMT, those with the lowest amount of impairment may have little room to improve on the standardized testing, leading to a ceiling and/or floor effect on the assessments (Cope et al., 2010). These findings indicate that individual characteristics may significantly influence the treatment outcome, and that personalized therapy based on a child's level of impairment may be required in order to maximize rehabilitation outcomes.

Bonnier and colleagues (2006) conducted an experiment that tested the effects of a day camp model of CIMT in 9 adolescents with hemiplegic CP. The participants were self-motivated, as they all volunteered to take part in the study; all participants were between 13 and 18 years of age (mean age = 15 years, 4 months) and experienced mild impairments in their affected arms. CIMT was administered for 7 hours per day, during which a restraining glove was worn; participants engaged in sports, group activities, and specifically chosen novel tasks that were practiced during camp (Bonnier et al., 2006). One of the novel tasks was a game called Frisbee golf; the objective of this game was to throw a Frisbee with the affected arm across a 350 foot field in as few throws as possible. Following the camp, the authors reported that hand skills had improved in several categories of motor performance; no changes were observed for grip strength or for a manipulation-rotation task which involved rotating pegs on a pegboard. It is possible that fine motor tasks, such as the manipulation-rotation task, would require more practice to master than the gross motor skills assessed in this study, which may explain in part why improvements were only observed on those tasks involving gross motor skills following CIMT. In particular, a significant increase in scores was observed on sub-section 5 of the Bruininks-Oseretsky Test of Motor Proficiency (Bonnier et al., 2006); this assessment measures participants' ability to bounce, throw, and catch a ball with one and two hands, as well as to pivot and manipulate the position of their fingers with their eyes closed (Braininks, 1978). To a great extent, the observed improvements were maintained at the 5-month follow-up assessment (Bonnier et al., 2006). In addition, it was noted that all participants showed improvement in the Frisbee golf task; this demonstrates that performance using the hemiplegic arm can improve with practice, even when the task is novel (Bonnier et al., 2006). It is interesting that these authors selected to practice a skill that is commonly taught in physical education classes (Bernstein, Phillips, & Silverman, 2011; Drake et al., 2012; Hall et al., 2012); this increases the application of the functional outcomes to the everyday lives of these individuals, as achieving proficiency in this skill will allow them to participate more fully in physical education classes with their peers at school. The authors note that in this particular study, the participants were all highly motivated to improve, a consideration that must be made when interpreting the results (Bonnier et al., 2006).

Charles and Gordon (2007) conducted an intervention in which 8 children aged 5-11 (mean age = 8 years, 7 months) with mild to moderate impairments received CIMT for 10 out of 12 consecutive days, and wore a sling on their less-affected arm for 6 hours each day. The children were engaged in play during the therapy sessions; in addition, functional activities, such as dressing, eating, and feeding were performed (Charles & Gordon, 2007). In this study, all of the participants had received CIMT 12 months prior; this study, therefore, was ultimately testing the effects of a second CIMT intervention. The authors reported that the improvements observed following the initial bout of CIMT were maintained 12 months post-intervention, and that the second intervention allowed the children to make even further gains (Charles & Gordon, 2007). In addition, the caregivers’ perceptions of an increase in both the amount and quality of use of the affected limb were retained at the 12 month follow-up, and these perceptions further improved following the second intervention. Because of the developmental curve of children during their growth and maturation, the authors suggest that it may be beneficial to perform repeated CIMT interventions as well as long-term follow-ups in this population (Charles & Gordon, 2007).

Studies that have used CIMT in alternative settings, including day camp settings, have reported lasting functional benefits for children with hemiplegic CP following the intervention. The studies discussed have demonstrated that the observed benefits are mostly maintained several months following the intervention; many of these studies have used reduced dosages of CIMT, which further supports the effectiveness of alternative forms of CIMT interventions. In all, many studies have used CIMT in children with hemiplegic CP; many of them have demonstrated the importance of this intervention for stimulating functional improvement in the affected limb. Though the currently available research in the area of CIMT in children with CP demonstrates promise, the results obtained in this area of research have exhibited some definite inconsistencies with regards to the extent of the therapeutic benefits observed following CIMT (Hoare et al., 2007; Wolf, 2007; Huang et al., 2009). This is likely due to a number of factors, including inconsistent methodology across studies, the application of a variety of assessment methods, the yet-to-be established optimal dosage, and possible individual characteristics that may affect the treatment outcome, such as age, motivation, and participant compliance (Hoare et al., 2007; Wolf, 2007; Huang et al., 2009). The discussion of personal participant factors that may influence the outcomes of a therapeutic intervention reveals an important point to consider in this area of research: the issue of statistical versus clinical significance.

The Issue of Statistical Versus Clinical Significance

Wolf (2007) published a paper criticizing the inconsistent methodologies and findings of studies using CIMT in children affected by CP; Wolf points out that the issue of statistical versus clinical significance must be considered, as the "time when the generation of a significant *p* value was proof positive of the efficacy of a treatment approach has passed" (p.1219). He asserts that it is more important in current research to demonstrate minimal clinical significance of a treatment, as this evidence is more meaningful to patients, clinicians, and funding agencies (Wolf, 2007). Important clinical changes or improvements are typically defined according to what the clients and/or caregivers deem to be relevant, meaningful, and practical improvements (Kvien, Heidberg, & Hagen, 2007); clinical improvements are improvements of relevance measured in a clinical trial, or the minimal meaningful change that occurs at an individual level (Kvien et al., 2007). For example, Cope et al. (2010) found that children with moderate impairment experienced the greatest functional gains following CIMT; Charles et al. (2001) found that two out of three children in their study experienced lasting functional benefits following CIMT. Finally, de Brito Brandão, Mancini, & Fonseca (2010) reported that while no improvements were observed on the standardized motor tests, participants demonstrated improvements in functional skills and independence following the CIMT intervention. Despite the inconsistencies observed in the study designs and outcome measures, it is important to consider the clinical significance of such functional gains; the studies performed by Cope et al. (2010), Charles et al. (2001)., and de Brito Brandão et al. (2010) demonstrate the importance of clinical significance, as CIMT had the ability to positively affect the lives of many of these children in a relevant and meaningful way by facilitating their daily functioning.

Within the population of children living with CP, individual differences are important to consider, as each child living with CP experiences his or her surroundings in a different way; there are many types of CP, many severities, and many additional impairments that can vary from one child to the next (Bax et al., 2006). In addition, there are many types of intervention available for CP, including surgical, pharmacological, and motor interventions (Law et al., 1997; Boyd et al., 2001; Bjornson et al., 2007; Anttila, Autti-Rämö, Suoranta, Mäkelä, & Malmivaara, 2008). As a result of these differences, in addition to the uniqueness of each child, each participant in a CIMT study will have varying needs as well as different areas of difficulty and ability. Recruitment can be challenging for these types of studies, and many of the samples collected using this population are small (Lavinder, Taub, & Gentile,1998; Charles et al., 2001; Brekke et al., 2004; Naylor & Bower, 2005; Fergus et al., 2008; Coker, Lebkicher, Harris, & Snape, 2009; Lee, Byun, & Chun, 2009; Stearns, Burtner, Keenan, Qualls, & Phillips, 2009; Al-Oraibi & Eliasson, 2011). In order to effectively address the uniqueness of each child's situation, a personalized therapeutic program would represent the ideal intervention. Due to the cost of such an endeavour, researchers have worked to find ways to employ interventions such as CIMT in ways that can be personalized to each child, by promoting the practice and shaping of many useful functional activities such as eating, dressing and toileting. The functional outcomes of interventions such as CIMT should be considered in the context of clinical importance, and not solely within the confines of statistical significance; in addition, personal factors that may influence the outcome of the intervention should be considered.

In the current study, the interaction that occurs between the child and the therapist conducting the assessment sessions was investigated as a possible factor influencing the results of the assessments performed; it is possible that the strength of the C-T interaction may affect the children's performance during the assessment sessions, which would ultimately impact their scores on the assessments. It is possible that in overlooking this potentially important therapeutic relationship, previous studies have obtained mixed results; in other words, if a child's performance during the assessment session is not reflective of his or her actual abilities, the results of the study will not accurately reflect the therapy's effects.

Part II: Child-Therapist Alliance

Examining the C-T Interaction

The current study sought to examine the C-T interaction as a possible factor influencing the perceived outcome of a modified CIMT intervention in children with hemiplegic CP. It has been previously demonstrated that the interaction, or alliance, between the child and the therapist may influence the success of the therapy (McLeod & Weisz, 2005; Liber et al., 2010; Shirk et al., 2011). For this reason, it was our intention to analyze this relationship in the context of a CIMT intervention in order to gain a better understanding of its potential influence on the perceived treatment outcome in children with spastic hemiplegic CP. Specifically, the way in which the child interacts with the therapist may affect the effort that the child puts forth on motor tasks; consequently, the measurements obtained from the motor assessments may not accurately reflect the child's true motor abilities. For example, if the child is not engaged by the therapist, then he or she may not perform the tasks to the best of his or her ability (McLeod & Weisz, 2005). This would compromise both the accuracy and the validity of the assessment scores, and would influence the perceived outcome of the intervention. Examining the C-T alliance by videotaping and systematically coding the assessment sessions will allow the researchers of this study to determine if the alliance between the child and therapist affects the child's performance on the assessment measures; this aspect of the current study is unique, and has not been formally measured in previous research using CIMT in individuals with CP.

Though the C-T interaction has not yet been investigated in children with CP undergoing a modified CIMT intervention, its importance was acknowledged by Gordon and colleagues (2006; 2007), who performed two CIMT interventions in children with spastic hemiplegic CP. The authors reported that the ability to capture a child's best motor performance – particularly when the participants are younger children – may be challenging (Gordon et al., 2006; Gordon et al., 2007); it for this reason that we will investigate the potential influence of the C-T interaction on our ability to capture each child's true motor capabilities. The C-T interaction has the potential to affect the perceived outcomes of the intervention, and it will therefore be discussed and interpreted in this context. Previous studies have consistently reported the need to investigate individual factors that may influence the outcome of a CIMT intervention (Lavinder et al., 1998; Charles et al., 2006; Charles & Gordon, 2007; Cope et al., 2010; Case-Smith, DeLuca, Stevenson, & Ramey, 2012; Wang et al., 2013); the investigation of the C-T interaction will address one of these individual factors. In fact, since the relationship between the child and the therapist may depend upon many factors, such as the child's age, level of impairment, and motivation, the investigation of the C-T interaction encompasses multiple personal factors that are unique to each child. Though multiple factors may contribute to the overall observed C-T alliance, only the actual C-T interaction itself will be measured and analyzed in the current study.

Measuring Alliance

Due to the relatively new application of the concepts of alliance to child therapy, Shirk et al. (2011) note that there is no 'gold standard' for measuring C-T as of yet; however, the Therapy Process Observational Coding System – Alliance (TPOCS-A; McLeod, 2001) scale has been used in several studies, and has been demonstrated to be a valid and reliable assessment of the C-T alliance in children (McLeod & Weisz, 2005; Liber et al., 2010; Shirk et al., 2011). The TPOCS-A scale was used in the current study to investigate the possible influence of the C-T interaction on the treatment outcome.

Support in the Literature for TPOCS-A

Several studies have been performed that have used the TPOCS-A scale to assess the C-T interaction (McLeod & Weisz, 2005; Liber et al., 2010; Shirk et al., 2011). McLeod and Weisz (2005) conducted a study in which 22 children (mean age = 10 years, 3 months) with anxiety and depressive disorders (termed 'internalizing disorders') had their therapy sessions coded using the TPOCS-A scale. There were 20 therapists involved in the treatment of the 22 children; the authors hypothesized that a strong C-T and parent-therapist alliance would yield a more successful treatment outcome in this population. The coders used were graduate students with both coding and clinical experience working with this population. There were two interviews that were videotaped and scored; the interviews were approximately 3 hours in length, and took place 15 months apart. The results demonstrated that both the C-T alliance and the parent-therapist alliance were positively related to youth treatment outcomes (symptomatology in this case); however, the C-T and parent-therapist alliances were found to be independent of one another (McLeod & Weisz, 2005). This suggests that the child and therapist can experience a relationship that is independent of the parent's feelings towards the therapist or the therapy session. Another group of authors used the TPOCS-A to analyze the C-T alliance in 34 children aged 6-13 years (mean age = 9 years, 9 months) with a diagnosis of an anxiety disorder; this study examined the C-T alliance before, during, and following a cognitive-behavioural therapy intervention (Chiu, McLeod, Har, & Wood, 2009). The results of the study demonstrated that improvement in the C-T alliance over the course of the therapy predicted better post-treatment outcomes. The results further suggested that a strong C-T alliance assessed early in treatment was associated with a decrease in symptomatology at mid-treatment, and higher treatment satisfaction at post-treatment (Chiu et al., 2009). From these results, it seems that a strong C-T alliance may promote successful therapeutic outcomes; a strong C-T alliance may in fact be needed to maximize treatment outcomes in children.

Summary

In all, the current research seeks to accumulate support for the benefits of implementing CIMT in a more natural setting for children with spastic hemiplegic CP. It will additionally examine the C-T interaction as a potentially important factor influencing the child's performance during the assessment sessions, which would ultimately influence the perceived outcomes of the intervention. This research will attempt to both replicate the findings of previous studies in this area, as well as contribute something unique to this body of literature in the analysis of the personal interaction that each child experiences with the assessing therapist.

SIGNIFICANCE OF THE RESEARCH

This study will add to the scientific literature regarding the use of CIMT in children with CP; it will also attempt to address the shortcomings of previous research in the area. Previous research has yielded inconsistent results when applying CIMT to the pediatric population affected by CP (Hoare et al., 2007; Wolf, 2007; Huang et al., 2009). The inconsistency of the results obtained in this research area can likely be attributed to a number of factors, including inconsistent methodology across studies, the application of a variety of assessment methods, and possible individual characteristics or 'personal factors' that may have an effect on the treatment outcome.

Justification of Methodology

Participants in this study included only children aged 5-9 years old; this is the strictest age range in the literature for this type of study second to Hsin et al. (2012), who had an age range of 6-8 years. The CIMT duration and intensity are also highly variable in the literature; this study used a day-camp model, which was chosen due to its suitability as both an economically sustainable and child-friendly model for this population. Other studies have used intensive training techniques when employing a CIMT intervention in this population; these types of studies often involve many hours of rigorous practice with the affected limb in a clinical setting (DeLuca et al., 2006; Charles & Gordon, 2007; Taub et al., 2004). Intensive CIMT interventions require significant amounts of time with PTs and OTs; the services rendered by these specialists are costly, and the model used in this study greatly reduces the number of PT and OT hours, thereby significantly reducing the cost of this type of intervention. Since neuroplasticity is more effective in the developing brain of both animals (Martin et al., 2011) and humans

(Sutcliffe et al., 2007), the ideal candidates to receive CIMT would be young children; school-aged children – and possibly those even younger – are more likely to want to engage in a therapy that appears pleasant and interesting to them. In the present study, children were engaged in stimulating and age-appropriate group activities and games that allowed them to interact with peers, build friendships, and practice using their affected limb simultaneously. The day camp model used in this study addresses the needs of this population by providing an engaging environment that is less strenuous and more appealing than an intense clinical intervention.

Purpose and Overall Contribution

The present study employed a day camp model to test the effects of CIMT in children aged 5-9 years with spastic hemiplegic CP; for several reasons, studies that take place in settings outside of the clinic have been gaining attention in recent years. Perhaps most importantly, the need to intervene for children in natural settings in order to promote the transfer of learned skills to functional activities is being increasingly acknowledged (Eliasson, et al., 2011; Case-Smith et al., 2012; Chen et al., 2012). Studies in a day-camp setting have been demonstrated to be effective; however, only a handful of studies have employed this cost-effective model in children with CP, and the age range of participants has been variable in previous studies (Bonnier et al., 2006; Aarts et al., 2010; Gilmore et al., 2010). By applying a modified form of CIMT in a day camp setting, while narrowing the age range significantly from those of previous studies, it was hoped that evidence would be provided supporting a more economically sustainable and child-friendly therapeutic model that promotes the transfer of skills from a clinic to a more natural setting.

In addition to investigating the benefits of CIMT in children with CP, the current study intentionally considered the personal factors of each child in the context of the intervention; this was accomplished by analyzing the C-T interaction during the assessment sessions. If a child is not inclined to perform to the best of his or her ability during an assessment session (due to personality, lack of motivation, etc.), then a child's true motor capabilities may not be captured, and an accurate reflection of the therapy's success may not be obtained from analyzing that assessment session. In the current study, the C-T interaction was analyzed in order to determine if there was an observable effect on the results obtained during the assessment sessions. Results obtained from this analysis may elucidate whether the client's individual experience and/or the collaborative C-T relationship influence the treatment outcomes following a CIMT intervention in children with spastic hemiplegic CP, and may inform future research in this area.

The overall purpose of this study was to determine if any functional benefits are observed in children with spastic hemiplegic CP following a CIMT intervention. Past studies have shown that CIMT is able to increase the child's spontaneous use of the affected limb in daily tasks and self-care activities (e.g. dressing, feeding, and toileting; Charles & Gordon, 2007; Cope et al., 2010). In many studies, these improvements last for months (Bonnier et al., 2006; Charles & Gordon, 2007; Cope et al., 2010); more research is needed in this area to support the effectiveness of CIMT in children with spastic hemiplegic CP. This study will also investigate the C-T alliance as one personal factor that may influence the perceived outcomes of CIMT. The results from this study will contribute to the scientific literature on CIMT in the pediatric population affected by spastic hemiplegic CP, and may help to shape future interventions for individuals with upper-limb impairment. Spastic hemiplegic CP is a relevant pediatric disorder that affects a significant population; research in the area of motor rehabilitation for children with CP is necessary. This study will build on the work of previous researchers in an attempt to find economically sustainable and effective ways to improve the daily functioning of children affected by spastic hemiplegic CP.

HYPOTHESES AND OBJECTIVES

Objectives of the Research

1. To investigate the effects of constraint-induced movement therapy in the context of a two-week day camp for children aged 5-9 years with a diagnosis of spastic hemiplegic cerebral palsy.

2. To investigate the interaction between the child and the therapist performing the assessment sessions as a possible factor influencing the perceived treatment outcomes of constraint-induced movement therapy.

Specific Hypotheses of the Research

1. Constraining the less affected upper limb for 7 hours per day during a day camp taking place over 9 days will induce functional benefits for the more affected limb following the intervention.

2. The improvements observed in the more affected limb as a result of constraint-induced movement therapy will persist at the 3-month follow-up assessment.

3. The strength of the child therapist interaction will affect a child's performance during the assessment session; specifically, those with stronger alliances will score higher on motor assessments administered during the assessment session, while those with weaker alliances will score lower on the assessments.

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SECTION 2: OVERVIEW OF THE PROPOSED RESEARCH

PROPOSED RESEARCH FRAMEWORK

World Health Organization: The International Classification of Functioning, Disability and Health (WHO-ICF)

Model Overview

In 2001, the World Health Organization (WHO) introduced a classification system intended to simplify the task of measuring health and disability at both the individual and population levels (WHO, 2001). The International Classification of Functioning, Disability and Health (ICF) acknowledges that every human being can experience a health condition at some point during the lifespan, and that all individuals can therefore experience some degree of disability (WHO, 2001). The WHO-ICF considers individual, environmental, and societal perspectives when discussing disability; body functions and structures are considered, as are the domains of activity and participation (WHO, 2001). The ICF underlines the importance of contextual factors in the analysis of disability, and thus also considers environmental and personal factors in its framework (WHO, 2001). By shifting the focus from cause to impact, the ICF has become an important model that seeks to place all forms of disability on a similar plane where they can be reasonably compared.

Applications of ICF

The ICF is used for functional status assessment, goal setting, treatment planning and monitoring, and outcome measurement (WHO, 2001). The ICF is intended to describe individuals with any disease or condition that affects their ability to function typically, and because every human may experience some form of health decrement at some point, the ICF model considers disability to be a universal human experience

(WHO, 2002). The ICF has helped to expand the thinking of researchers beyond the idea of repairing impairments in children with cerebral palsy (CP); rather, the primary objective is to promote each child's function and full participation in daily life activities. All children enrolled in the current study had a diagnosis of spastic hemiplegic CP, and all had some level of impairment of function on one side of the body. The 'Activity' section of the WHO-ICF model describes the different tasks that the individuals affected by the disorder are able to do; the activities that the individuals can perform are often limited by some aspect of the disorder in question, which in the case of the current participants is spastic hemiplegia. The goal of implementing a CIMT intervention is to improve both the amount and quality of use of the affected side; by improving each child's capacity to perform daily activities such as self-care tasks and independent mobility, it is anticipated that this will ultimately improve the child's participation in those activities. Increased participation in various daily activities can lead to various developmental gains, such as improved social skills; such gains may transfer to school, home and social environments, which would only further improve the child's functional status.

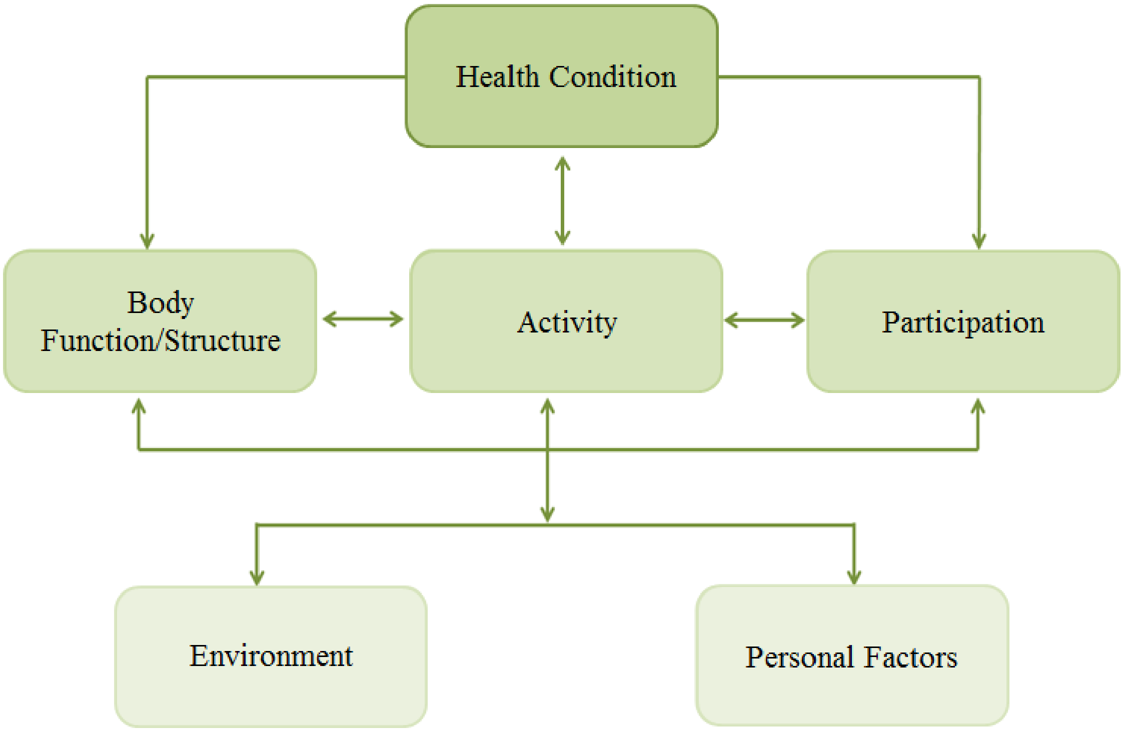
Finally, the personal factors of each child are important to consider; these factors include such things as the child's personality, home environment, and community involvement. A child's temperament has the ability to influence his or her activity and participation in various tasks; for example, a child's level of confidence and self-esteem may have an impact on his or her perseverance. Specifically, children who lack confidence may be easily discouraged following a failed attempt to perform a motor task; this may decrease the likelihood that the attempt will be made in the future. Children with high levels of self-esteem and confidence, on the other hand, may be more inclined to demonstrate repeated efforts. This would ultimately have an impact on what each child is able to do; children with higher levels of confidence may acquire proficiency in a greater number of tasks than children with lower levels of confidence, and may thus participate in more activities. A child's home environment consists of various factors; familial structure and number of siblings are two factors which play an important role in the child's functional status. For example, children with two caregivers in the household may receive more attention and encouragement to practice using the affected limb than children with only one caregiver in the household. Similarly, if children with CP have multiple siblings, caregivers may not have as much time to provide encouragement to use the affected limb. In contrast, children with CP who have siblings may naturally participate in more activities through active play with those siblings.

Finally, there are many extra-curricular activities available to children within their communities; an increasing number of these initiatives are directed towards children with disabilities, with the objective of promoting inclusion as well as enhancing physical and social skills in these children (Taub & Greer, 2000). If children are enrolled in such activities, this will likely promote the use of the affected limb in a motivating, group setting; children will also have the opportunity to interact with other children and subsequently develop their social skills, which may lend them increased confidence and self-esteem. Developmental gains such as these may then internally motivate children with CP to further engage in various activities, thus further promoting improvement in their functional status.

Cerebral Palsy, CIMT and the ICF

Figure 1 presents the WHO-ICF model that will be used to discuss the classification of the population to be used in this study using the ICF; each category of the model will be discussed with respect to this population.

Figure 1: General WHO-ICF model for the classification of health conditions and functioning



Health Condition

All of the participants in the current study had a diagnosis of spastic hemiplegic cerebral palsy. Different severities of spasticity and hemiparesis exist in those with this form of CP, and all levels of both symptoms were included in the study.

Body Function and Structure

The participants in the study experienced an insult – a lesion or other abnormality – to their developing brains in the perinatal period of life (Bax, Tydeman, & Flodmark, 2006). Lesions that occur on the right side of the brain typically result in paresis of the left side of the body, while lesions that occur on the left side of the brain result in paresis of the right side of the body. Due the reduced activity of the affected side, muscle contractures may have developed in some of the children, which affect the child's mobility and performance of everyday tasks (Smith, Lee, Ward, Chambers, & Lieber, 2011; Smith, Chambers, Subramaniam, & Lieber, 2012). The participants may also experience muscle weakness and/or fatigue due to a lack of use of the affected side. Cerebral palsy is also commonly associated with various secondary conditions, such as seizures, sensory impairments and learning disabilities (Odding, Roebroeck, & Stam, 2006; Prasad, Verma, Srivastava, Das, & Mishra, 2011); any secondary impairments or conditions that were present were noted but were not a cause for exclusion from the study.

Activity

The ‘Activity’ category of the model describes the different tasks that the individuals affected by the disorder are *able to do*; the activities that the individuals can perform are often limited by some aspect of the disorder (WHO, 2001). By identifying what the individuals are capable of doing prior to treatment initiatives (e.g. grip strength, range of motion, grasping capabilities), intervention attempts can be planned appropriately to target certain activities for improvement. The types of activities that this intervention hopes to improve for the participants include fine motor tasks, gross motor tasks, and other motor skills. Examples of skills that were targeted for improvement in this intervention include feeding, dressing, and other everyday tasks.

Participation

The participation section of the model refers to what the child actually does in his or her daily life (i.e. what activities the child takes part in outside of therapy; WHO, 2001). When implementing a motor intervention, it is hoped that the child’s participation in certain activities will increase or improve as the child’s ‘Activity’ improves. In other words, if the CIMT intervention improves the child’s ability to accomplish certain tasks, it is hoped that the child will perform these tasks more frequently in daily life. In this study, the tasks that the children perform in everyday life were assessed using various questionnaires that were filled out by parents/guardians and camp counselors. These questionnaires explored the child's daily functioning and level of independence in performing various functional activities. The children's abilities to perform certain tasks will also be assessed using standardized motor tests.

Environmental Factors

Environmental factors are important when discussing a disability or health condition, as the context in which disability is assessed and treated may significantly influence the outcome of the treatment attempt (WHO, 2001). In this study, participants attended a day camp; the camp ran daily for 9 consecutive weekdays, and the children performed age-appropriate activities and interacted with other children affected by spastic hemiplegic CP. The activities performed by the children during the day camp remained constant for all participants involved; furthermore, there was one camp counselor for every two children, which gave each child an opportunity to receive a personalized experience during the study. This is important, as several authors have suggested that a personalized therapeutic experience might be essential in order to maximize treatment outcomes (Charles, Wolf, Schneider, & Gordon, 2006; Gordon, Charles, & Wolf, 2006; Cope et al., 2010; Case-Smith, DeLuca, Stevenson, & Ramey, 2012). The purpose of the day camp model was to engage and motivate the children while promoting the use of the hemiplegic side in an active and enjoyable environment. Gilmore and colleagues investigated participant opinions regarding a CIMT intervention that took place in a day camp setting (Gilmore, Ziviani, Sakzewski, Shields, & Boyd, 2010); the participants commonly reported that they were encouraged to be in a place where they had the opportunity to interact with other children who were similar to them. Children reported feeling less alone and less different in this setting (Gilmore et al., 2010); as a result, conducting a therapeutic intervention such as CIMT in a day camp setting may motivate children and ultimately improve their participation, which in turn would allow them to practice skills, and ultimately improve the number of activities that they are able to do.

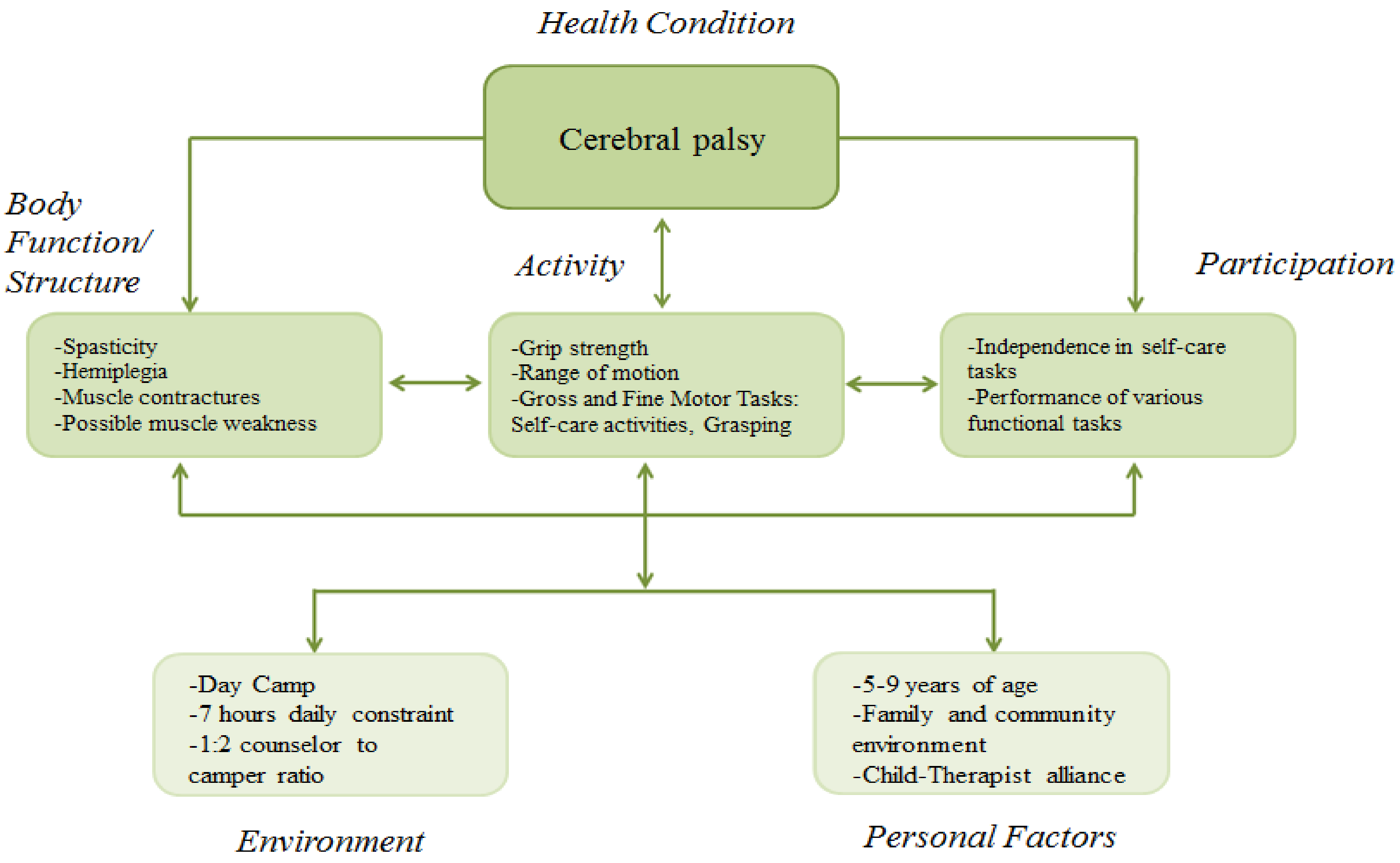
Personal Factors

All of the children in the study were boys and girls between 5 and 9 years of age at the beginning of the camp; all participants were able to ambulate independently and participate in a camp setting. Each child will have different family structures, and each family will likely provide different levels of motivation and exhibit different beliefs, all of which affect each child's current situation with respect to his or her health condition. The personal factors of each child are particularly relevant to the current study, as examining a child's interaction with the acting therapist is a unique experience. Each child will have a different temperament, personality, and social life, all of which would likely affect the interaction that occurs between the child and therapist.

Summary

Figure 2 summarizes the WHO-ICF model as it can be applied to the current study. By taking the individual, functional, and environmental aspects into consideration, this study will aim to promote functional improvements in the affected limb for children with spastic hemiplegic CP. The study will employ modified CIMT in the context of a day camp setting; this treatment program is designed to facilitate the transfer of any functional gains into daily life. It is hoped that the intervention will enable children to experience improvements in their abilities to perform various tasks, and that as a result, their participation in these tasks outside of the therapeutic setting will increase.

Figure 2: WHO-ICF model illustrating the model of the current study



Ashley M. E. Thompson (2013)

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SECTION 3: MANUSCRIPT 1

EFFECTS OF CONSTRAINT-INDUCED MOVEMENT THERAPY IN CHILDREN AGED 5-9 YEARS WITH SPASTIC HEMIPLEGIC CEREBRAL PALSY: A DAY CAMP MODEL

Abstract

In children with spastic hemiplegic cerebral palsy (CP), modified constraint-induced movement therapy (CIMT) has been demonstrated to be an effective form of therapy that yields beneficial functional outcomes for participants. The current study's objective was to examine the effectiveness of modified CIMT in the context of a day camp model in six children aged 5-9 years with a diagnosis of spastic hemiplegic CP. Participants were assessed prior to the camp, immediately following the camp, and three months later; assessments included the Quality of Upper Extremity Skills Test (QUEST), the Pediatric Evaluation of Disability Inventory (PEDI), range of motion, grip strength, and caregiver reports. Results demonstrated significant improvements in quality of use of the upper extremity following the intervention as measured by the Grasps ($p=0.02$) and Protective Extension ($p=0.01$) sub-sections of the QUEST, as well as increased social function as measured by the PEDI ($p=0.02$); improvements were maintained at the 3-month follow-up. Analysis of each individual participant yielded additional information on clinically significant improvements as a result of the CIMT intervention. The results of this study indicate that modified CIMT is effective in inducing lasting and meaningful changes in the pediatric population with spastic hemiplegic CP.

Cerebral Palsy

The term cerebral palsy (CP) defines a group of movement and posture disorders caused by a permanent but non-progressive abnormality in the fetal or infant brain (Bax, Tydeman, & Flodmark, 2006). The development of the brain is interrupted due to an interfering event that damages or otherwise influences the expected patterns of maturation; the result may be a lesion or a malformation in the immature brain (Azzopardi et al., 1999; Cowan et al., 2003; Bax et al., 2006). Though the causes of these abnormalities vary (Cowan et al., 2003; Robinson et al., 2009), CP occurs on average in 1 out of 500 children (Blair & Watson, 2006), making it the most common paediatric physical disability (Stanley, Blair, & Alberman, 2000; Reid, Carlin & Reddihough, 2011). The most common form of CP is spastic hemiplegic CP, which is characterized by rigid movements as well as asymmetric motor impairment, and affects approximately one third of individuals diagnosed with CP (Hagberg, Hagberg, Beckung, & Uvebrant, 2001; Platt et al., 2007; Reid et al., 2011). Spasticity is the most prominent symptom of spastic hemiplegic CP, and refers to a "motor disorder characterized by a velocity-dependent increase in muscle tone, with exaggerated tendon jerks, resulting from hyperexcitability of the stretch reflex, as one component of the upper-motor neuron syndrome" (Lance, 1980). CP is classified as an upper motor neuron syndrome, as it results from damage that occurs to the pyramidal tract and/or surrounding areas; damage to the upper motor neurons leads to a variety of impairments in children with CP (Odding, Roebroeck, & Stam, 2006), and the type and severity of symptoms observed is dependent upon both the location and the extent of the lesion incurred (Odding et al., 2006). In hemiplegia, one side of the body is more impaired than the other; the upper limb is typically more affected than the lower limb, and the impairments compromise the child's ability to reach, grasp, release and manipulate objects (Sakzewski, Ziviani & Boyd, 2009). The impairments experienced by children with hemiplegic CP affect many aspects of their daily lives; these functional limitations ultimately interfere with proper motor development in multiple ways. Independence while performing self-care tasks, ability to fully participate in play and other group settings, and overall daily function are some of the areas in which children with hemiplegic CP experience difficulties (Brady & Garcia, 2009).

Constraint-Induced Movement Therapy

The most commonly employed motor therapies for treating individuals with CP are administered by physical therapists (PTs) and occupational therapy (OTs), and include neurodevelopmental therapy (NDT) techniques (Boyd, Morris, & Graham, 2001). Effective treatment methods for the upper limb impairment observed in CP are needed; constraint-induced movement therapy (CIMT) is a relatively new motor intervention that began gaining attention as a potential therapy for children with CP more than a decade ago (Boyd et al., 2001).

CIMT is a form of rehabilitative therapy that involves constraining the less affected limb, while simultaneously training the more affected limb (Taub & Crago, 1998). The originally proposed recommendations for employing CIMT as a therapeutic technique were to restrain the less-affected limb for 90% of the individual's waking hours, and to perform intensive movement therapy with a trained therapist for six hours per day over a two-week period (Taub, Crago, & Uswatte, 1998). However, in the population of children with hemiplegic CP, researchers must contend with unique challenges; the intensity of the traditional CIMT therapy may be too great to retain the attention of young children (Brown, Rensburg, Lakie, & Wrigh, 2008; Gilmore, Ziviani, Sakzewski, Shields, & Boyd, 2010). The therapy should ideally include a variety of child-geared activities as well as intermittent breaks in order to maximize compliance and effectiveness (Bonnier, Eliasson & Krumlinde-Sundholm, 2006; Brown et al., 2008; Aarts, Jongerius, Geerdink, van Limbeek & Geurts, 2010; Cope et al., 2010; Gilmore et al., 2010). In addition, following the originally proposed guidelines for CIMT would require between 60 and 84 hours of physical therapy per week; this renders traditional CIMT a costly intervention, both financially and in terms of therapists' time. Having CIMT delivered by camp counselors who are highly trained and monitored by PTs or OTs would require much less PT/OT time, and is a substantially more cost-effective way of implementing CIMT. Together, these factors suggest that the traditionally proposed form of CIMT may not illustrate the most economically feasible and sustainable therapeutic model for children with CP. As such, researchers have been challenged to modify CIMT for the pediatric population affected by spastic hemiplegic CP. Many studies have used modified forms of CIMT, where alterations in the intensity and/or duration of the therapeutic technique are used (Charles, Lavinder, & Gordon, 2001; Bonnier et al., 2006; Charles & Gordon, 2007; Fergus et al., 2008; Cope et al., 2010).

Taub and colleagues performed two separate controlled trials of CIMT in children with hemiplegic CP; one trial used traditional paediatric CIMT (Taub, Ramey, DeLuca, & Echols, 2004), while the other used a modified form of CIMT (Taub et al., 2011). The traditional form consisted of 6 hours of CIMT per day for 21 consecutive days in children aged 8 months to 8 years, while the modified form consisted of 6 hours per day for 3 weeks of weekdays only (15 days) for children aged 2-6 years; it was found that the results were at least as good in the modified trial as they were in the traditional trial (Taub et al., 2011). This suggests that a less intensive form of the therapy may suffice to produce positive effects in this population, which is more economically sustainable as well as less time-intensive for families participating in the interventions. Many studies have replicated these findings, demonstrating modified CIMT's ability to increase the child's spontaneous use of the affected limb in day-to-day tasks and self-care activities (e.g. dressing, feeding, and toileting; Charles & Gordon, 2007; Cope et al., 2010), as well its capacity to improve motor performance as measured by standardized motor assessments (Taub et al,. 2004; DeLuca, Echols, Law, & Ramey, 2006). In many studies, the improvements are maintained several months later at follow-up; this demonstrates the ability of modified CIMT to induce lasting functional benefits in this population (Taub et al., 2004; Bonnier et al., 2006; Charles & Gordon, 2007; Cope et al., 2010). Many recent studies have begun to examine the effects of CIMT in settings outside of the clinic (Bonnier et al., 2006; Aarts et al., 2010; Cope et al., 2010; Taub et al., 2011; Rostami & Malamini, 2012). The importance of transferring the shaping and practice of the unaffected limb to more natural settings is gaining attention in the field, as an increasing number of studies appear to be implementing home exercise programs into interventions (Naylor & Bower, 2005; Chen et al., 2012; Hsin et al., 2012; Rostami & Malamini, 2012). More research is needed in this area to support the effectiveness of modified CIMT applied in natural settings for children with spastic hemiplegic CP.

Chen et al. (2012) conducted a home-based randomized controlled trial with 47 children aged 6-12 years with spastic hemiplegic CP; 24 children were assigned to the CIMT group, and 23 children were assigned to the usual care group. The intervention lasted 4 weeks, and involved individualized therapist-based training at home for 3.5-4 hours per day, 2 days per week (Chen et al., 2012). It was found that the CIMT group improved more than the usual care group on standardized tests of motor performance, including the Grasping section of Peabody Developmental Motor Scale and Pediatric Motor Activity Log. In addition, the CIMT group displayed better hand use and quality of hand use than the usual care group (Chen et al., 2012). Finally, the CIMT group displayed better performance on some aspects of reaching control, including shorter reaction times (Chen et al., 2012). Another group of authors performed an experiment that examined the effects of a day camp model of CIMT in 9 adolescents with hemiplegic CP (Bonnier et al., 2006). The participants were self-motivated, as they all volunteered to take part in the study; participants were between 13 and 18 years of age, and experienced mild impairments in their affected arms. CIMT was administered for 7 hours per day, during which time a restraining glove was worn; during camp hours, participants engaged in sports, group activities, and specifically chosen novel tasks (Bonnier et al., 2006). Following the camp, the authors reported that hand skills had improved in almost all categories; to a great extent, these improvements were maintained at the 5-month follow-up assessment. Another group of researchers employed CIMT in a day camp setting, applying a reduced amount of therapy of 3 hours per day for 3 days per week; however, the duration of the intervention was extended to 8 weeks, as the authors hypothesized that a longer but less intense CIMT intervention would yield better functional outcomes (Aarts et al., 2010). It was found that the children in the treatment group improved to a much greater extent than those in the usual care group, who received only 1.5 hours per week with a PT or an OT (Aarts et al., 2010).

Studies that have used CIMT in more natural settings, including day camp settings, have resulted in lasting functional benefits for children with spastic hemiplegic CP following the intervention. Previous literature has demonstrated that the observed benefits are mostly maintained several months following the intervention, indicating a persistence of the effects of modified CIMT in this population. These studies in alternative settings are of particular importance to the current study, as a day camp model was used in the current study to test the effectiveness of CIMT in this population. Further, the importance of implementing CIMT in a natural setting is supported by the World Health Organization's International Classification of Functioning, Disability and Health (WHO-ICF; WHO, 2001); the WHO-ICF describes the reciprocal relationship between the individual and his or her environment, and the way in which this interaction contributes to the individual's overall functional status.

According to the WHO-ICF, disability must be considered in the context of body structures and functions, environmental factors, activity and participation (WHO, 2001). These factors, in addition to the personal factors and characteristics of each individual, interact with one another and contribute to the overall health condition and function of that individual. The activity of the child refers to what he or she is able to do, and participation refers to what the child actually does outside of the therapeutic setting (WHO, 2001). The goal of any implemented intervention is to increase the activity of the child, such that participation may improve. By improving the child's ability to perform upper limb tasks in a lasting way, modified CIMT is promoting functional changes that permit children with hemiplegic CP to increase their participation in various tasks outside of therapy. Performing the intervention in a natural setting takes into account the importance of the individual’s environment, and will likely facilitate the transfer of any learned skills into daily functioning. The current study sought to improve the functional use of the affected limb in participants, in hopes that their capacity to better utilize the affected arm would allow them to perform more tasks incorporating this arm, including self-care tasks and other daily activities.

The objective of the current study was to determine whether a two-week (9 days in total) day camp model of CIMT, delivered by highly trained camp counselors supported by OTs, was effective in improving functional outcomes according to the WHO-ICF for children aged 5-9 years with a diagnosis of spastic hemiplegic CP.

Methods

Study Design

The current study involved a pre-assessment that took place one week prior to the intervention, a 9-day intervention during which participants wore a splint on their unaffected arm for 7 hours per day and participated in activities that promoted the use of the affected arm, a post-assessment that took place one week after the intervention’s end, and a 3-month follow-up assessment. Participants acted as their own controls, and any changes observed following the CIMT intervention were analyzed both on an individual and at a group level.

Recruitment

Children with a diagnosis of hemiplegic CP between 5 and 9 years of age were recruited through the use of a flyer that advertised the camp; in addition, the flyer was posted on bulletin boards at the Children’s Treatment Centre (CTC), and the camp was also advertised to other CTCs in the area. Potential participants were also directly informed of the study by OTs at the CTC.

Participants

Inclusion criteria for the study required that participants have a diagnosis of spastic hemiplegic CP and be between 5 and 9 years of age. Participants had to be able to walk independently without an ambulation aid, have the cognitive and social ability to participate in a camp setting, and be willing to travel to the CTC for the duration of the camp, for the intake assessment, and for the three assessment sessions. Regardless of any secondary conditions or any other impairment or symptoms present, all interested children who satisfied the above criteria were included in the study. Exclusion criteria were as follows: (1) Any orthopedic (correctional) surgery on the affected upper limb and/or (2) dorsal rhizotomy. A total of six children took part in the study (four males and two females; mean age = 6 years, 4 months). This study was approved by the University's Research Ethics Board and the CTC's Ethics Committee. Informed consent from a parent/guardian of each child as well as child assent was obtained for all participants during an intake session; during this session, additional information about each participant was gathered on a supplemental form, and participants were fit for a splint.

Procedures

Participants were enrolled in a day camp ('Cast Camp') where CIMT was administered for 7 hours per day; Cast Camp took place over a two-week period during the summer, for a total of 9 days (this was due to a holiday which took place on the Monday of the first week).

The Splint

Each participant was given a Benik© splint to be worn on the dominant hand. The model selected was the W323 with Volar Pan extension and finger separators; this splint effectively immobilizes the wrist, fingers and thumb of the restrained hand (Figure 3). This splint was chosen due to its ability to prevent the children from flexing and extending the wrist, as well as to prevent the fingers from grasping. The participants were also able to select their own colours for their two-toned splint. The splint was worn only during camp hours and was applied and removed by camp staff each day.

Figure 3: Benik© splint model W323 with volar pan extension

Modified Constraint-Induced Movement Therapy

The splint was worn for 7 hours per day while the children attended the camp; all children who attended ‘camp’ were participants in the study, and all children wore the splint. The camp was led by three counselors, all of whom were university students. All summer camp counselors underwent a two-week intensive orientation and training session at the CTC in order to become trained as camp counselors for children with various physical and developmental disabilities. The three counselors for Cast Camp additionally underwent two one-hour training session with OTs at the CTC in order to be prepared to effectively deliver CIMT in a day camp setting. In addition, two out of three of the camp counselors, including the camp coordinator, were involved in Cast Camp in 2011; the camp coordinator was further involved in Cast Camp in 2010. The ratio of camp counselors to participants was 1:2; OTs at the CTC dropped in to the camp daily, and closely monitored all activities that were being performed by the participants. Camp activities were prepared by the experienced camp counselors using templates of activities from previous years. OTs at the CTC provided feedback to counselors in order to ensure that all activities performed during camp specifically promoted the use of the affected hand; gross manipulation tasks as well as precision tasks were targeted in the daily activities. Examples of the activities included finger painting, crafts, and team-building activities such as theme days with structured activities planned according to these themes. Counselors also monitored all feeding times and provided a motivating environment in which children were encouraged to use their affected hands as much as possible. Modified CIMT was administered in a camp setting by highly trained camp counselors for 7 hours per day for 9 consecutive weekdays, for a total of 63 hours of CIMT; as such, these conditions are fairly close to the originally proposed guidelines of 6 hours per day for 14 days, but represent a more cost-effective model of CIMT.

Assessments

Several assessments were used in this study, all aimed to evaluate the function of the affected hand as well as to determine the parents' perceptions of the children's functioning. All assessments were conducted by an OT who was not the primary OT for any of the participants, and who was not involved in Cast Camp in order to avoid any influential bias. The assessing OT did not know any of the participants prior to the study, and she did not have access to their medical records; the only time the OT interacted with the participants was during the assessment sessions. The assessments took place on three separate occasions, and were scheduled at the convenience of the families one week prior to the camp's beginning, one week following the camp's end, and three months following the camp's end.

The assessments used in this study included the Quality of Upper Extremity Skills Test (QUEST; DeMatteo et al., 1993), the Pediatric Evaluation of Disability Inventory (PEDI; Haley, 1992), and a questionnaire developed by the OTs at the CTC (CTC Questionnaire) based on the Canadian Occupational Performance Measure (Law et al., 1990); the CTC questionnaire was developed specifically for Cast Camp, and is only used in this setting at the CTC. The QUEST is a standardized assessment of motor performance that evaluates a child's 'all or nothing' ability to complete a variety of tasks; all items are graded as a yes/no, with a 'yes' meaning that each child can perform the task completely (DeMatteo et al., 1993). The QUEST is scored out of 100 points, and is comprised of four general domains: Dissociated Movements, which includes items assessing various upper limb movements, Grasps, which involves grasping and manipulating objects, Weight Bearing, which includes measures of balance and posture, and Protective Extension, which measures a child's protective reflexes when balance is lost (DeMatteo et al., 1993). The PEDI is a questionnaire that is completed by the child's caregiver; this measure is also scored out of 100. The PEDI measures the ability of the child to participate in self-care tasks (e.g. dressing, feeding), mobility capabilities (e.g.

indoor and outdoor movements), and social function abilities (e.g. communication and social play; Haley, 1992).

The CTC Questionnaire was also completed by the caregiver, and assesses any changes observed in the frequency and/or spontaneity of use of the affected limb; further, it assesses the child's ability to perform a variety of self-care tasks, and addresses both the parents' evaluations of the importance of the child improving in each area as well as their levels of satisfaction with the child's current level of performance for each task (Appendix 6). Each item is assessed on a scale of 1-10, with scores closer to 10 indicating a higher level of performance, importance or satisfaction. The 'Performance' section of the CTC Questionnaire assesses only the child's ability to perform each task on a scale of 1-10, and this section of the questionnaire was also completed by all three camp counselors for all six participants on the first and final days of camp (Appendix 7). The purpose of this was to triangulate our data in order to better understand each child's functioning; obtaining ratings of each child's performance from parents, camp counselors, and OTs during the assessment sessions provides multiple perspectives for analysis. Ultimately, this triangulation allows us to better detect any possible changes observed in the functional use of the affected limb following Cast Camp.

Additional assessments included measures of range of motion (using a goniometer), grip strength (using a Baseline® sphygmomanometer), and assessment of spasticity and level of impairment using the Modified Ashworth scale (Bohannon & Smith, 1987), the Gross Motor Function Classification System (GMFCS; Rosenbaum, Palisano, Bartlett, Galuppi, & Russell, 2008), and the Manual Ability Classification System (MACS; Eliasson et al., 2006). Range of motion was measured in the affected arm only, and included such measures as elbow and wrist flexion/extension, finger and thumb flexion/extension and shoulder rotation. Grip strength in both hands was measured using a modified sphygmomanometer; the device consists of a hand-held pump containing water connected to a pressure gauge that measures grip strength in pounds per square inch (PSI) when squeezed (maximum possible score is 15.5 PSI) . Measuring grip strength in the less affected limb serves as a comparative tool between assessments to determine if there were any adverse effects of the constraint on the less affected limb. Participants were seated, with the shoulder in the neutral position and the elbow flexed at a 90° angle when grip strength measurements were taken. Three successive measurements were taken in the unaffected limb and then the affected limb; a rest period of about 15 seconds was given between trials, which was the time required to read and record the score. The mean of the three trials was used for data analysis. The Modified Ashworth level assessment was made by the OT on the elbow joint of the affected limb during each of the three assessment sessions, and the MACS level was determined by asking the caregivers of each participant to select from a list of five options the level that best described their child’s function. Caregivers were asked to read the descriptions for each level carefully, and to select the level that best described their children’s overall ability in everyday life.

Statistical Analysis

Analysis of variance was employed using a repeated measures design for the QUEST as well for grip strength and the caregiver reports on the CTC questionnaire. The non-parametric Wilcoxon matched pairs test was used to analyze the independent reports given from camp counselors and caregivers on the ‘Performance’ section of the CTC questionnaire. The paired samples t-test was used for the PEDI, which was administered to caregivers at only the first and final assessments. For all measures, percent changes were calculated for each participant over the three assessment sessions, such that changes were considered in the context of each participant acting as his or her own control.

Results

Participant Information

Individual characteristics for each participant can be found in Table 1. Considerable variability was present in the sample; as such, each child was used as his or her own control and analyzed separately for many of the measures employed.

Table 1: Participant Characteristics

Participant	Age	Gender	Affected Side	MACS Level (I-V)	GMFCS Level (I-V)	Modified Ashworth PRE, POST, 3MO (0-4)	Previously attended Camp	Additional Impairments
1	6	Male	Right	I	I	1, 2, 2	Yes (2011)	None
2	6	Male	Right	II	I	NT, 2, 1	Yes (2011)	None
3	9	Male	Right	II	II	2, 1, 1	No	Learning Disabilities; Sensory Integration Disorder; Social Isolation; Difficulty transitioning from preferred activities to less preferred; Angry (sometimes physical with outbursts); Impulse control difficulties
4	5	Male	Right	II	II	3, 3, 2	No	Learning Disabilities
5	5	Female	Left	I	I	0, 0, 0	Yes (2011)	None
6	6	Female	Right	II	I	0, 0, 0	No	Febrile Seizures; Difficulty keeping up with other children in physical activities

Motor Assessments

Range of Motion

All participants but one experienced lasting improvements in active range of motion for at least one joint measured, though the joint and degree of improvement varied between participants. The improvements observed for active range of motion by participant are listed in Table 2 (Note: The participant who did not experience improvements in active range of motion experienced very mild impairments)

Table 2: Active Range of Motion Improvements by Participant (measured in degrees with goniometry; only categories in which improvements were observed are listed)

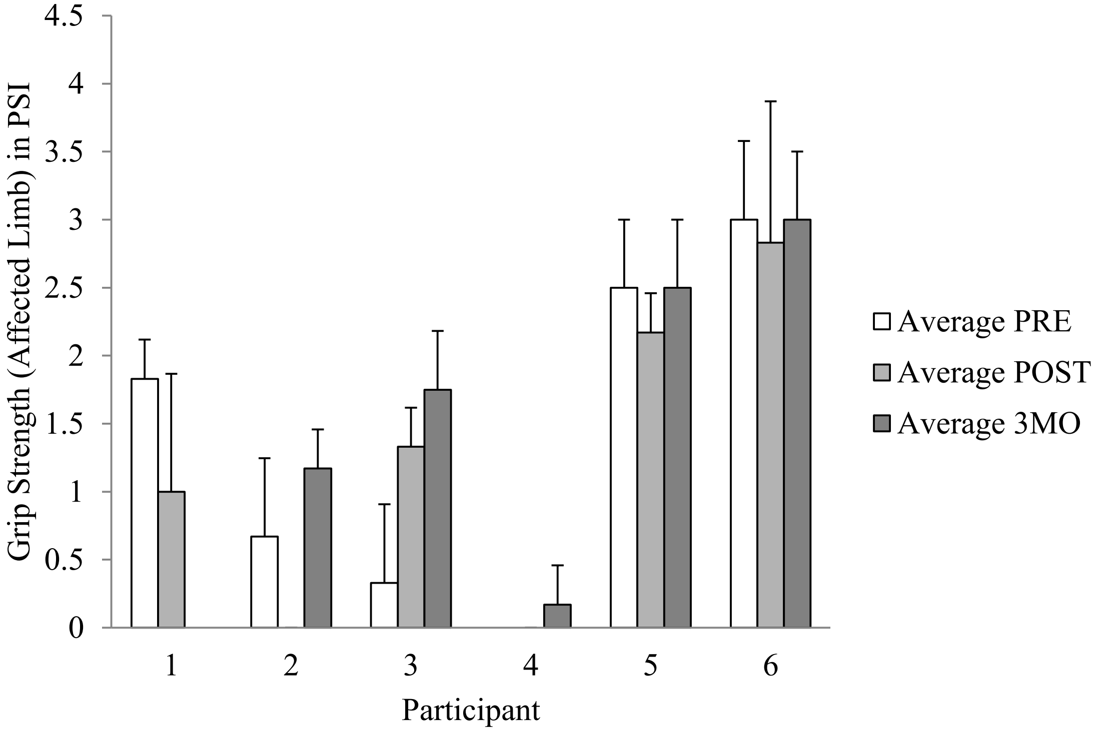
Participant	Area Tested	Pre-Assessment Score	Post-Assessment Score	3-Month Follow up Score	Overall % Improvement
1	Wrist Flexion	66	80	80	21.2%
2	Shoulder External Rotation	52	90	90	73.1%
	Wrist Extension	42	70	80	90.5%
	Thumb Flexion	To pad of D1	To PIP of D2	Full	N/A
3	Finger Flexion	Limited	Full	Full	N/A
	Thumb Extension	Limited	Limited	Full	N/A
	Thumb Abduction	To PIP of D2	Full	Full	N/A
4	Shoulder Abduction	102	NT	180	76.5%
	Shoulder Flexion	160	130	180	12.5%
6	Radial Deviation	12	26	20	66.7%

*PIP = Proximal Interphalangeal finger joint; D1, D2 = Digit 1, Digit 2, respectively. NT=Not Tested

Grip Strength

The majority of participants did not experience a statistically significant change in grip strength in the affected limb as a result of the intervention (Figure 4). Participants 2 and 3, however, experienced an increase in grip strength in the affected arm; participant 2 experienced a 74.6% increase in grip strength, while participant 3 experienced a 430.3% increase (Table 3). No significant differences were found in grip strength for the unaffected arm (the arm that was splinted during camp) directly following the intervention (*p*=0.87), or between the initial assessment and the 3-month follow-up (*p*=0.69).

Figure 4: Mean grip strength (in PSI) including standard deviation (SD) in the affected limb by assessment session (each bar represents the average of 3 trials)



QUEST

The scores for all participants on the QUEST are represented in Table 3. Significant group differences were observed on the Protective Extension sub-section of the QUEST over time (Figure 5; assumption of sphericity satisfied, *F*(2,10)=7.167, *p*=0.01); this sub-section measures participants' ability to use both of their arms to prevent a fall when balance is lost. Further analysis of the results indicated that a statistically significant improvement was observed immediately following the intervention (*p*=0.05), and Protective Extension scores did not decline at the 3-month follow-up (*p*=0.22 between assessments 2 and 3). Regardless of GMFCS or MACS level, the participants improved as a group and maintained those improvements at the 3-month follow-up.

Table 3: (a) QUEST scores by participant and by category and (b) Group Means by category at the pre-assessment, post-assessment, and 3-month (3MO) follow-up assessment

(a)

		Participant					
QUEST Section	Session	1	2	3	4	5	6
Total Score	PRE	72.97	81.98	69.80	61.79	92.01	91.62
	POST	72.44	89.94	68.27	49.27	95.65	97.35
	3MO	71.97	84.56	79.85	46.87	94.66	99.22
Dissociated Movements	PRE	70.31	75.00	70.31	54.84	93.75	92.19
	POST	62.50	82.81	67.19	53.23	100.00	93.75
	3MO	56.25	76.56	78.13	51.56	95.31	96.88
Grasps	PRE	69.57	69.57	60.87	56.52	82.61	82.61
	POST	78.26	78.95	65.22	52.17	82.61	95.65
	3MO	82.61	73.68	82.61	47.37	100.00	100.00
Weight Bearing	PRE	92.00	100.00	98.00	74.00	100.00	100.00
	POST	74.00	98.00	74.00	50.00	100.00	100.00
	3MO	74.00	88.00	92.00	0.00	100.00	100.00
Protective Extension	PRE	60.00	83.33	50.00	0.00	91.67	91.67
	POST	75.00	100.00	66.67	41.67	100.00	100.00
	3MO	75.00	100.00	66.67	41.67	83.33	100.00

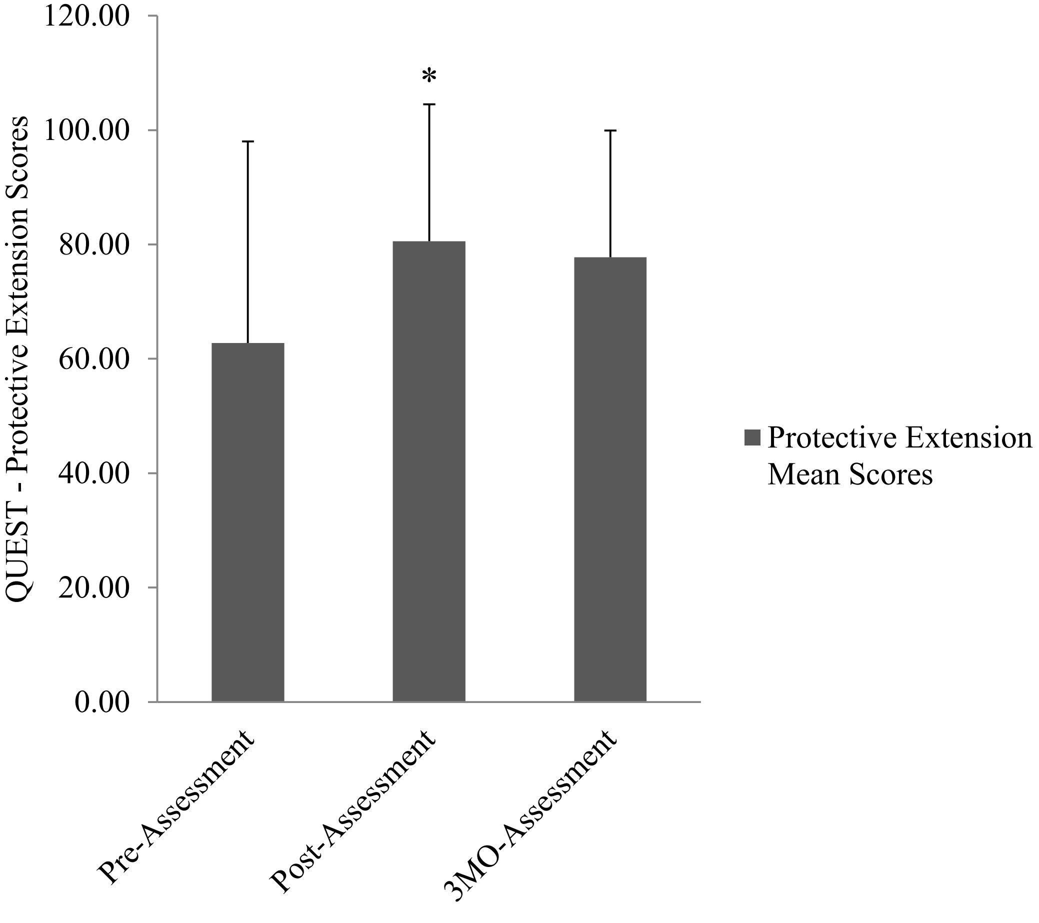
*Participant 4 did not complete Weight Bearing section in Session 3

(b) QUEST Group means by sub-section and assessment session

Session	Total QUEST Score	Dissociated Movements	Grasps	Weight Bearing	Protective Extension
PRE	78.36	76.07	70.29	94.00	62.78
POST	78.82	76.58	75.48	82.67	80.56*
3MO	79.52	75.78	81.05*	90.80	77.78

Participant 4 not included in 3MO group mean for Weight Bearing, as he did not complete this section of the QUEST at this session (* indicates statistical significance, α=0.05)

Figure 5: Mean Protective Extension Scores on QUEST including SD. Asterisk (*) indicates statistical significance, α=0.05.



Further, as a group, the participants experienced improvements in the Grasps sub-section of the QUEST (*F*(2,8)=9.90, *p*<0.01; Figure 6a). Further analysis of the results indicated that significant improvements were observed between the first and final assessment sessions (*p*=0.02; see Table 4 for percent changes for each participant). Participant 4 did not comply with the assessor's requests, which rendered it difficult to accurately assess his grasping skills; for this reason, participant 4 was excluded from this particular analysis. In Figure 6, the bars represent group means, which increased between the pre-assessment and post-assessment, and again between the post-assessment and 3-month follow-up. When participant 4 was included in the analysis, improvements in the Grasps sub-section of the QUEST demonstrated a trend toward significance (*p*=0.059), though these results did not reach statistical significance. Participant 3 also demonstrated a notable overall improvement in total QUEST score, improving his score by 14.40% between the first assessment and the 3-month follow-up. No significant changes were observed on the Dissociated Movements or Weight Bearing sub-sections of the QUEST.

Figure 6: Mean improvements in Grasps scores over time on QUEST including SD (participant 4's scores are excluded; * indicates statistical significance).

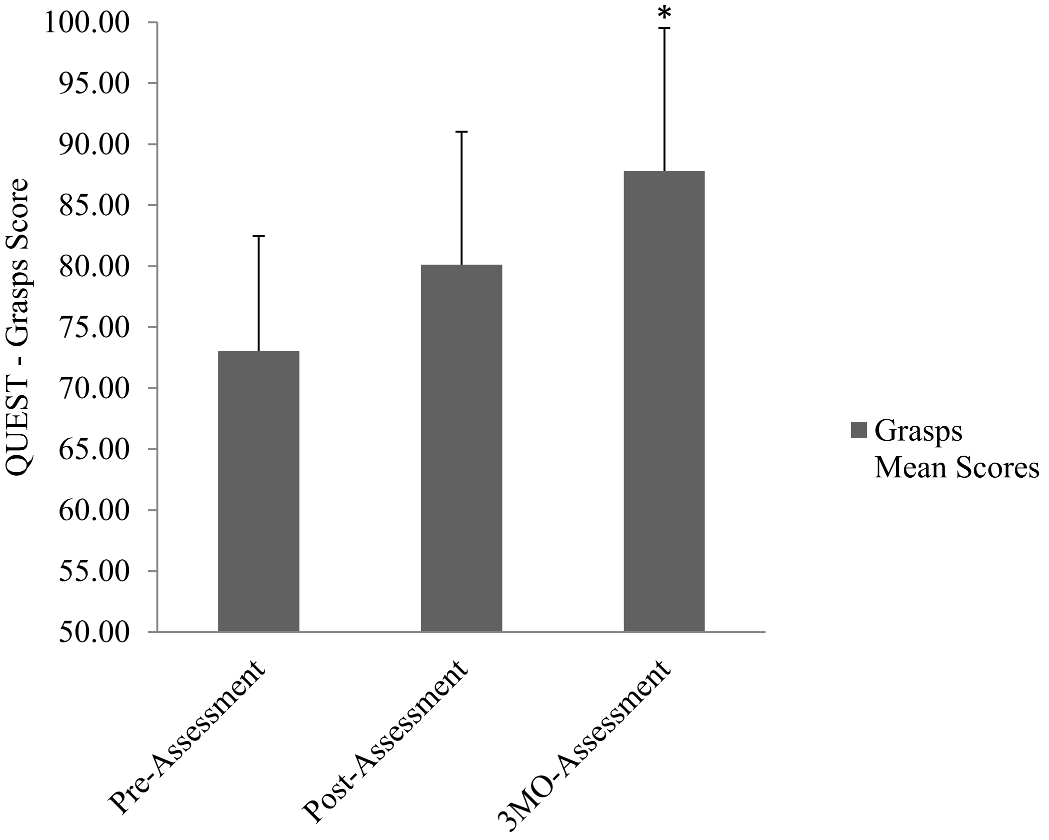


Table 4: Individual percent changes on Grasps sub-section of QUEST

Participant	Percent Change (PRE to POST)	Percent Change (POST to 3MO)	Percent Change (PRE to 3MO)
1	+12.49%	+5.56%	+18.74%
2	+13.48%	-6.68%	+5.9%
3	+7.15	+26.7%	+35.72%
5	0%	+21.05%	+21.05%
6	+15.79%	+4.55%	+21.05%

Caregiver Reports

PEDI

PEDI scores for all participants can be found in Table 5. Caregivers' responses indicated a significant improvement in social function skills following the intervention (*t*(5)=-3.37, *p*=0.02). No significant changes were observed in any of the other categories of the PEDI that evaluated the functional skills of the participants. No significant changes were observed in the caregiver assistance section of the questionnaire between the first and final assessments, which assesses each child's level of independence when performing various tasks. When analyzing the results by participant, however, some important clinical changes can be observed: in the category of independence while performing self-care tasks, participant 2 experienced a 30.4% increase after 3 months, participant 4 experienced a 28.9% increase, and participant 3 experienced a 13.9% increase. In all, three out of six participants demonstrated clinically important increases in independence when performing self-care tasks. Analysis of the remaining three caregivers' perceptions of participants' independence when performing self-care tasks revealed that one participant improved by 2.95%, one remained unchanged, and one decreased by 35.5% between the first and final assessments.

Table 5: Mean PEDI scores including SD by participant and by category including standard deviation at the pre-assessment, and 3-month follow-up assessment

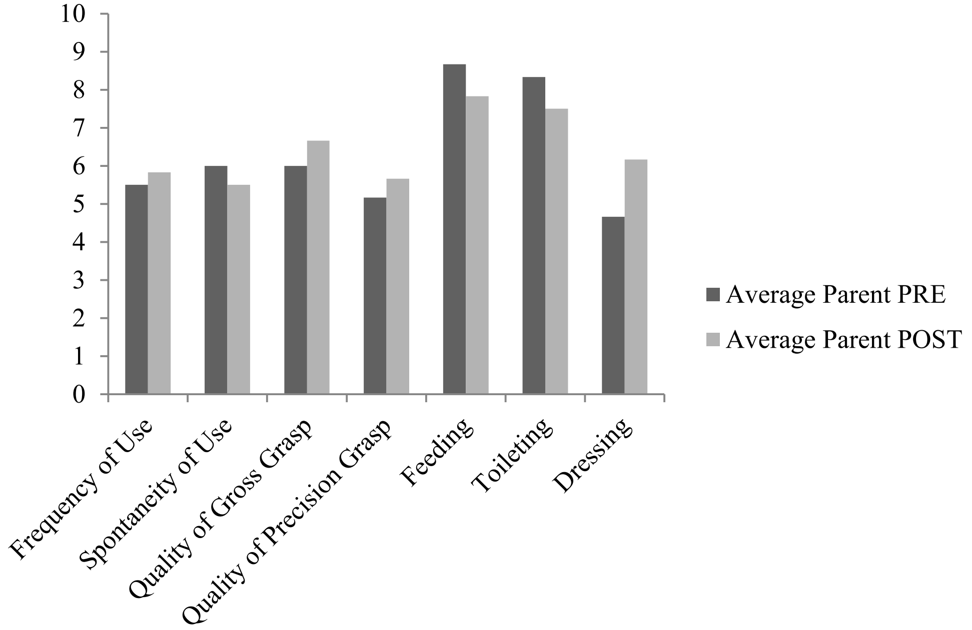
		Participant					
PEDI Section	Session	1	2	3	4	5	6
Functional Skills – Self-Care	PRE 3MO	68.3±1.8 63.9±1.7	69.1±1.8 70.0±1.8	58.0±1.6 60.5±1.6	64.6±1.7 65.3±1.7	72.6±2.0 75.9±2.3	73.6±2.0 79.0±2.8
Functional Skills – Mobility	PRE 3MO	63.9±1.7 70.0±1.8	66.8±1.8 70.0±1.8	67.6±1.8 60.5±1.6	65.3±1.7 65.3±1.7	63.9±1.7 75.9±2.3	68.3±1.8 79.0±2.8
Functional Skills – Social Function	PRE 3MO	64.6±1.7 68.3±1.8	67.6±1.8 69.1±1.8	66.0±1.7 66.8±1.8	63.9±1.7 64.6±1.7	70.0±1.8 71.7±1.9	70.8±1.9 71.7±1.9
Caregiver Assistance – Self-Care	PRE 3MO	74.5±4.7 76.7±5.2	76.7±5.2 100±0.0	55.7±3.5 63.4±3.5	69.6±4.0 89.7±10.3	83.2±7.2 83.2±7.2	100±0.0 64.5±3.6
Caregiver Assistance – Mobility	PRE 3MO	74.5±4.7 72.7±4.4	74.5±4.7 74.5±4.7	72.7±4.4 72.7±4.4	72.7±4.4 71.1±4.1	69.6±4.0 72.7±4.4	72.7±4.4 59.0±3.5
Caregiver Assistance – Social Function	PRE 3MO	57.9±3.5 60.1±3.5	61.1±3.5 61.1±3.5	53.4±3.6 48.6±3.8	59.0±3.5 59.0±3.5	60.1±3.5 60.1±3.5	60.1±3.5 62.2±3.5

CTC Questionnaire

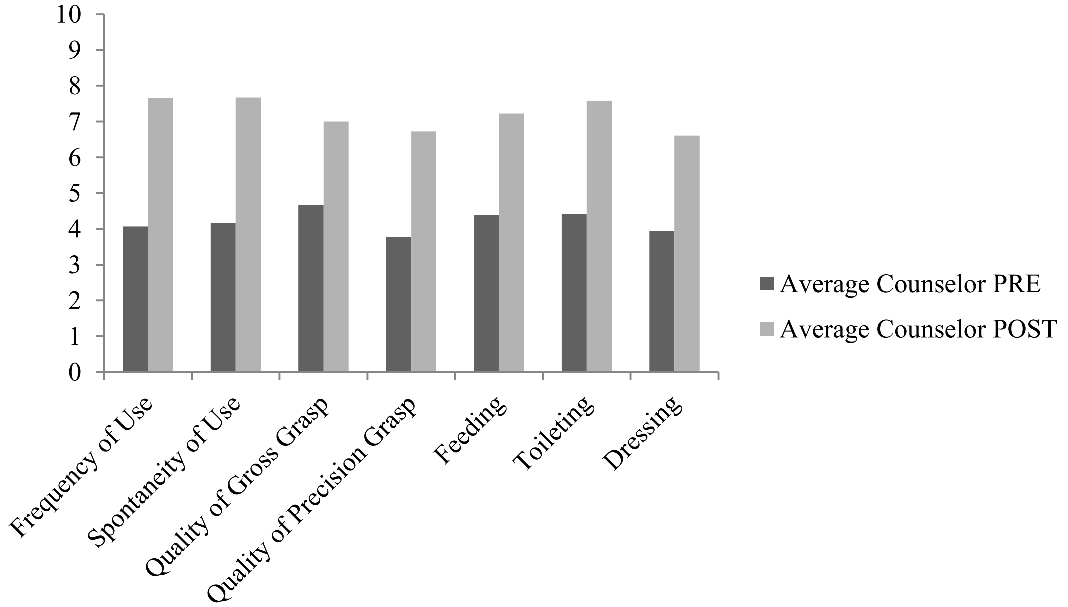
Both camp counselors and caregivers completed the ‘Performance’ section of the questionnaire on at least two occasions; the caregivers completed it at all three assessment sessions, while the camp counselors completed it at the end of the first and final days of camp. While there were no significant changes observed in the caregiver responses between the first and second assessment sessions (Figure 7a), the average counselor scores (average of the 3 counselors’ scores for each item) improved significantly over time (p=0.03). The ‘average counselor’ reported significant improvements for all participants in all seven sections of the CTC questionnaire between the first and final days of camp (Figure 7b). It was further found that caregivers consistently rated their children higher on the performance scale than did the camp counselors at the pre-assessment session (Figure 7c). In addition, no significant changes were observed in the caregivers’ responses on the performance section at the 3-month follow-up assessment.

Figure 7: Comparison of average caregiver and average counselor scores (average of 3 individual counselor scores) on 'Performance' section of the CTC questionnaire.

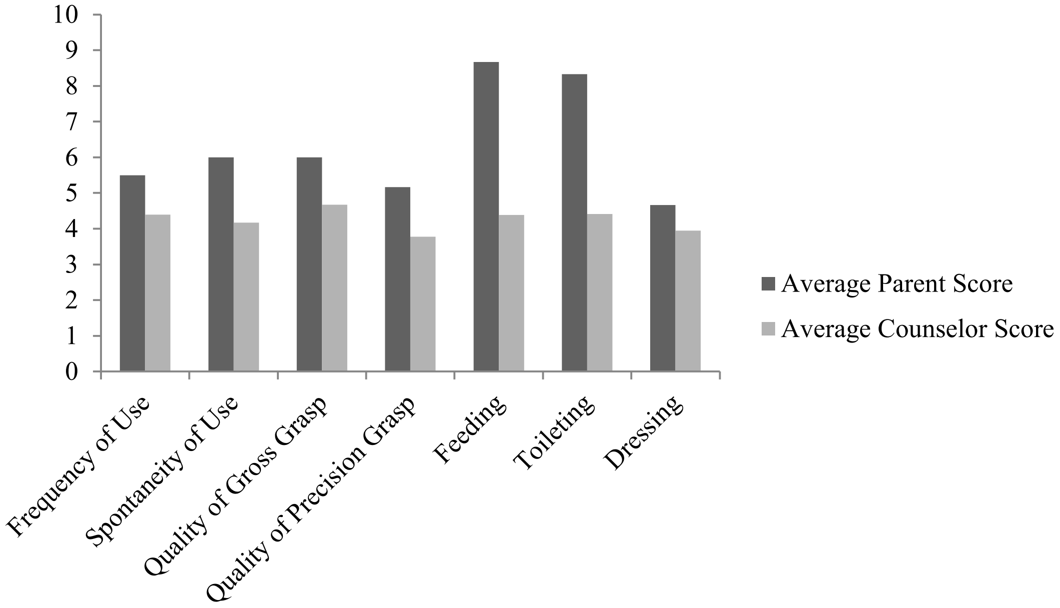
(a) Average parent scores at the pre and post-assessments



(b) Average counselor scores at the end of the first and last days of camp



(c) Comparison of average parent and average counselor scores at the first assessment time



Finally, no significant changes were observed in the caregivers' responses on the 'Satisfaction' section of the questionnaire over time. The 'Satisfaction' portion of the CTC questionnaire asks caregivers to rate on a scale of 1-10 how satisfied they are with their child's current performance in each area. When the responses to the 'Satisfaction' section of the questionnaire were analyzed by participant, it was found that overall improvements were seen in several individual areas (see Table 6 for a summary of the improvements observed). In each individual category of the CTC questionnaire, at least half of the caregivers' satisfaction increased between the initial assessment and the 3-month follow-up; the only exception to this was in the 'Frequency of Use' sub-section. Further, in the 'Feeding' sub-section, three of the caregivers reported an increase in satisfaction, while the other three reported no change in satisfaction over time. It should be noted, however, that all caregivers who reported no change in 'Satisfaction' gave the maximum score possible on each occasion for the 'Feeding' sub-section.

Table 6: Percent of caregivers who reported increased 'Satisfaction' on different categories of the CTC questionnaire between the first and final assessment sessions

Area Assessed	Percent Caregivers
Frequency of Use	33.33%
Spontaneity of Use	83.33%
Quality of Grasp (Gross)	50.00%
Quality of Grasp (Precision)	50.00%
Feeding	50.00%
Toileting	50.00%
Dressing	50.00%

Parents/guardians also completed a supplemental form providing additional information about the participants at the initial intake session; this supplemental information form was only administered to caregivers once. The purpose of the form was to gather additional information about each of the participants; the WHO-ICF framework informs researchers that personal factors are essential to consider in the context of motor interventions (WHO, 2001). As such, it was our intention to use this information in order to later analyze the data in the context of these personal factors where applicable. One of the sections involved quantifying the level of encouragement that the child is given to use the affected limb at home; the results from this section of the questionnaire are presented in Table 7. The results from this question were quite variable, with some parents reporting offering high levels of encouragement, while others offered very little encouragement to use the affected limb in the home environment.

Table 7: Encouragement given to use the affected arm (on a scale of 1-10)

Participant	Encouragement given (1-10)
1	3
2	5
3	7
4	9
5	6
6	5

Overall, improvements in various areas of the motor assessments administered were observed in both group means and individual analysis; in addition, some mixed results were obtained on both the motor assessments and caregiver reports.

Discussion

In the current study, children aged 5-9 years with a diagnosis of spastic hemiplegic CP took part in a CIMT intervention within a day camp setting for 7 hours per day for 9 consecutive weekdays. Clinical studies using modified CIMT have previously been demonstrated to be effective in the pediatric population with spastic hemiplegic CP (Taub et al., 2004; DeLuca et al., 2006; Fergus et al., 2008); modified CIMT has also been successfully applied outside of a clinical setting in this population, yielding positive outcomes for the youth involved (Bonnier et al., 2006; Cope et al., 2010; Chen et al., 2012). The results obtained in this study further support the use of modified CIMT in children with CP, as several overall benefits were observed following the intervention.

Improvements in the Grasps area of the QUEST motor assessment were observed for all participants who completed the assessment (Table 4); these results were statistically significant when the scores for participant 4 were excluded (Figure 6). This finding has important clinical implications, since many daily tasks require the children to effectively grasp and manipulate objects. Several of the activities performed during the camp were specifically geared towards improving grasp; as such, it was anticipated that participants would improve in this area. Previous studies have found that following CIMT, participants demonstrated statistically significant improvements in grasping ability (Case-Smith, DeLuca, Stevenson, & Ramey, 2012; Chen et al., 2012; Lin et al., 2012). In two out of three of these studies, follow-up assessments were performed; in both of these studies, the improvements were maintained 6 months following the intervention (Case-Smith et al., 2012; Lin et al., 2012). These findings support the results of the current study, and the functional implications of the improvements observed in the current study are both relevant and important. More efficient grasping capabilities would allow children to perform a variety of functional tasks with increased efficiency, including self-care tasks such as feeding and dressing; they may also allow increased participation in other activities such as play.

Statistically significant improvements were observed in the Protective Extension sub-section of the QUEST; these improvements were maintained at the 3-month follow-up (Figure 5). This finding is consistent with previous research demonstrating improvements on standardized tests of motor performance (Taub et al., 2004; DeLuca et al., 2006; Charles & Gordon, 2007; Fergus et al., 2008; Aarts et al., 2010; Cope et al., 2010; Aarts, Jongerius, Geerdink, van Limbeek & Geurts, 2011; Case-Smith et al., 2012; Chen et al., 2012). The improvements on the Protective Extension domain of the QUEST occurred regardless of GMFCS or MACS level; this demonstrates that regardless of level of gross motor or hand impairment, participants improved their Protective Extension scores following the CIMT intervention. Although the activities performed at camp did not specifically target protective extension skills for improvement, this finding is meaningful; an increase in the spontaneous use of the affected limb could have reasonably contributed to the improvements observed in Protective Extension scores. If children increased their spontaneous use of the affected limb, then it is reasonable to infer that they would be more inclined to use both arms to catch themselves when balance is lost. Children with CP often experience impairments in balance and motor control due to spasticity and muscle contractures (Chambers, 2001); these impairments can lead to falls, further supporting the relevance of the current finding of improved Protective Extension skills.

Although previous studies have reported improvements on tests of standardized motor performance, these studies have found varying degrees of improvement using a variety of different motor assessments. For example, DeLuca et al. (2006) found significant improvements only in the Dissociated Movements sub-section of the QUEST, which is inconsistent with the current study's findings; however, DeLuca et al. (2006) used a cohort with an age range of 7 months to 8 years, which is much wider than the current study's age range (all participants aged 5-6 years except for one aged 9 years). Case-Smith et al. (2012) found improvements on the Grasps and Dissociated Movements sub-sections of the QUEST following CIMT that persisted at the 6-month follow-up; these results differ slightly from those found by DeLuca et al. (2006), and support the current study's finding of improvements in grasp following CIMT. Charles et al. (2001) used the Jebsen-Taylor Test of Hand Function to measure motor performance (Jebsen, Taylor, Trieschmann, Trotter, & Howard, 1969); they found that two out of three of the children demonstrated improvements in their use of the affected hand following the intervention, but concluded that only one participant maintained these improvements at the 6-month follow-up. Ultimately, individual differences may affect the improvements observed on standardized tests of motor performance; in the current study, significant improvements were observed in the Grasps and Protective Extension sub-sections of the QUEST. The objective of the current intervention was to improve functional outcomes in the affected limb for children with hemiplegic CP; increased quality of use of the affected limb in the form of improved grasp and increased spontaneous use of the limb in the form of improved protective extension skills demonstrate the intervention's efficacy in this regard.

Lasting improvements in active range of motion were also observed for all but one participant; the participant who did not experience improvement, however, had very mild motor impairments. Though the area and amount of improvement varied between participants, all those who improved experienced important clinical improvements in range of motion of the affected upper limb. Previous studies have also examined range of motion in this population; several studies examine range of motion in order to confirm that the ability to move through the maximum active range is not hindered in the unaffected limb following CIMT (Taub et al., 2004; Bonnier et al., 2006; DeLuca et al., 2006; Stearns, Burtner, Keenan, Qualls, & Phillips, 2009). In other words, studies have examined range of motion in order to ensure that constraining the less affected upper limb does not negatively affect the less impaired upper limb in participants. Studies have consistently shown that active range of motion in the unaffected limb is not hindered following CIMT (Taub et al., 2004; Bonnier et al., 2006; Stearns et al., 2009); in addition, recent studies have demonstrated that CIMT is able to increase the active range of motion of the affected limb following the intervention (Taub et al., 2011; Xu, Wang, & He, 2012). The current study's results confirm both of these findings, as the range of motion in the unaffected limb was unhindered, and the active range of motion of the affected limb improved following the intervention. These gains in active range of motion presumably occurred because children were engaged in various activities during camp that encouraged them to move in new ways, ultimately leading them to practice moving the affected arm outside of the range which was typical for the children on a daily basis prior to the intervention. As a result of the 1:2 counselor to camper ratio, participants received a personalized experience at Cast camp, wherein each child's unique areas of difficulty were targeted for improvement. This personalized therapeutic experience may help explain some of the differences observed between participants in the areas of improvement for active range of motion. In addition, there was no negative impact on the range of motion of the unaffected limb; this demonstrates that a short-term motor intervention can be successfully applied without hindering the unaffected limb in developing children with hemiplegic CP.

Improvements in grip strength of the affected limb were also observed for two of the participants; in addition, no significant changes in grip strength were observed in the unaffected limb. This finding indicates that wearing the splint for 7 hours per day for 9 days did not have a negative effect on the unaffected limb of participants. This is important, as children with hemiplegic CP already experience difficulties with one upper limb; as such, it is important that any motor intervention aimed at improving the function of the affected limb does not impair the function of the unaffected limb. It should be noted that participant 4 did not comply with the assessor's requests and did not complete the grip strength measurement in the first assessment session; though he completed the assessment at the second and third assessments, he did not appear to put forth his best efforts in these sessions (Figure 4). Previous studies have also reported non-significant results for changes in grip strength following a CIMT intervention (Eliasson, Krumlinde-Sundholm, Shaw, & Wang, 2005; Charles, Wolf, Schneider, & Gordon, 2006; Gordon, Charles, & Wolf, 2006); It has been previously suggested that grip strength is difficult to measure in this population, due to potential limb deformity or extreme weakness (Taub et al., 2007). Demonstrating grip strength in the affected limb may be seen as difficult work for the participants; support for this came from several of the participants during this portion of the assessment, who commented that their affected limb was 'broken' or 'didn't work', or complained that it was too hard to squeeze the apparatus with that hand, and attempted to use their unaffected limb for assistance. In addition, the activities performed during camp were not specifically selected to improve grip strength in the affected limb; as such, large gains in this area were not expected in this study.

Stearns and colleagues (2009), however, reported significant improvements in grip strength following a CIMT intervention in children with spastic hemiplegic CP (Stearns et al., 2009). Several possible reasons for which they observed significant improvements were noted by Stearns et al. (2009); two of these reasons included the use of activities that were designed to improve grip strength over the course of the intervention, and the repeated measurement of baseline and post-treatment grip, taking the average of grip on five separate days during each study phase. The authors increased the resistance of manipulative putty that was used on a daily basis during the intervention, and suggest that strengthening the affected upper limb may require this type of practice that increases in difficulty (Stearns et al., 2009). Further, they suggest that taking multiple grip strength measurements is beneficial for accuracy in this population, as this helps account for the variability of grip observed in children with spasticity (Stearns et al., 2009). The study by Stearns et al. (2009) performed an intervention in which grip strength was the primary target for improvement; in the current study, however, the primary goal was to observe improvements in functional outcomes. As such, the grip strength of the affected hand was not expected to increase considerably; still, clinically significant improvements in grip strength were observed for two participants in the current study, despite the fact that no statistically significant gains were observed.

Caregivers reported a significant increase in social function following the intervention on the PEDI, which appears to be an unintended benefit of the current study; previous studies have also reported increases in areas of social function following a CIMT intervention (de Brito Brandão, Mancini, & Fonseca, 2010; Hsin et al., 2012). Taub et al. (2004) reported positive subjective feedback from the parents of the participants following CIMT, who stated that their children demonstrated increased self-confidence, increased interaction with their environment, and new sensory awareness of their affected limb. Hsin et al. (2012) found that following CIMT, children in the treatment group improved more on domains of lasting well-being and social acceptance, emotional well-being and self-esteem when compared to the usual care group. Gilmore et al. (2010) looked at participants’ opinions of a day-camp model of CIMT, and found that participants enjoyed the feeling of being in a place where others were like them;

participants reported feeling more motivated as a result of this. This is relevant to the current findings, as increased feelings of self-confidence, self-esteem, and motivation may have resulted from the therapy's camp setting. This may have led to improved social function in participants, which represents a developmental gain that can positively influence many other areas of a child's life, including home, school, and community environments. In addition, 3 out of 6 of the caregivers reported improved independence for their children in the performance of self-care tasks following the intervention. These results are consistent with previous research, which has demonstrated that caregivers' perceptions of their children's ability to use the affected limb improves following CIMT (Taub et al., 2004; Bonnier et al., 2006; Charles & Gordon, 2007; Cope et al., 2010; de Brito Brandão et al., 2010). It is plausible that variability within the sample can account for the varying levels of improvement reported by caregivers on the remaining five sub-sections of the CTC questionnaire; still, important functional improvements were observed in the current study for some or all of the participants in at least one of the areas tested by the PEDI.

Differences in Modified Ashworth level were found for 4/6 participants between assessment sessions (Table 1). The Modified Ashworth scale is used for measuring muscle spasticity; it involves manually moving the arm through its range of motion to passively stretch specific muscle groups, and uses a five-point ordinal scale to grade the resistance encountered (Ashworth, 1964). Spasticity is a velocity-dependent response of the muscle to passive muscle stretching, representing one characteristic of the upper motor neuron syndrome (Lance, 1980); as such, changes in Modified Ashworth level would not be expected following a motor intervention. In the current study, however, changes in Modified Ashworth level were noted for some participants on different assessment occasions. It is important to consider that the Modified Ashworth scale is a behavioural measure; as such, it is dependent upon a therapist's observation and subsequent interpretation of a child's level of spasticity based on upper limb movement. Consequently, it is conceivable that this measure could vary from one assessment session to the next; the same OT performed all three assessment sessions for all participants, which increases the reliability of the results.

Strengths/Limitations

Though this study demonstrates a variety of benefits of modified CIMT in this population, it also identifies some of the methodological issues of clinical studies employing CIMT in the pediatric population affected by CP. Inconsistent results have been found in previous studies using modified CIMT in the pediatric population (Huang et al., 2009; Wolf, 2007); some authors have suggested that personal factors such as age, level of impairment and level of motivation ought to be considered when applying CIMT intervention in this population (Lavinder, Taub, & Gentile, 1998; Charles et al., 2006; Cope et al., 2010; Case-Smith et al., 2012; Wang et al., 2013). As such, the current study used children aged 5-9 years (66-111 months), which to the knowledge of the researchers, is among the strictest age ranges in the literature for this type of study. In fact, only one child was 9 years of age, and this child experienced various additional impairments, including learning disabilities, Sensory Integration Disorder, and social isolation; all other participants were either 5 or 6 years of age, with few or no additional impairments (Table 1). Levels of motor impairment, additional impairments, and motivation varied within the group, which may have had an influence on the outcomes observed. Three potential factors that may have influenced the outcomes in this study will be specifically discussed: potential caregiver bias, personal factors as defined by the WHO-ICF, and statistical versus clinical significance.

Potential Caregiver Bias

Camp counselors completed the ‘Performance’ section of the CTC questionnaire on the first and last days of camp; the purpose of this was to triangulate the data by acquiring parent, counselor, and OT reports of participants’ functioning, as well as to explore multiple perspectives on the children’s skills by comparing the camp counselor scores with the scores provided by caregivers. Camp counselors, who only spent time with the participants for the duration of the camp (and who did not know the participants otherwise), were not expected to present with any bias on their responses. Since the camp counselors were trained to promote the use of the affected limb during camp hours, had specifically coordinated camp activities with the intent of doing so, and spent 7 hours each day with the participants for 9 consecutive weekdays, it was expected that they would be able to provide a reasonably accurate assessment of each participant’s performance in several areas of function. In order to increase the objectivity of the counselor responses, the three counselors’ responses were averaged to produce the ‘average counselor’s response’, which was used in all graphical and statistical calculations. On the CTC questionnaire, camp counselors reported that all children improved in their performance in all sections of the CTC following the 9 days of camp; however, caregivers did not report similar results.

There were two major findings for the Performance section of the CTC questionnaire: first, the average counselor perceived greater improvements in the children's performance than did the caregivers between the first and second assessments. Second, caregivers consistently provided higher ratings for their children at the initial assessment than those provided by the average counselor. To address the differences in perceived improvement immediately following the intervention, one must consider the different roles as well as the different perspectives of caregivers and camp counselors. It is possible that the camp counselors observed improvements that caregivers did not observe due to the nature of the camp itself; at camp, the children were actively engaged in activities that specifically promoted the use of the affected limb. For example, children were verbally encouraged to use their affected limb at lunch time during camp; similar verbal encouragement may not have been provided to the same extent during meal times at home. In addition, camp counselors were specifically instructed to encourage as well as to monitor the use of the affected limb in order to facilitate motor gains; as such, counselors may have been more focused than caregivers on observing and assessing things such as the quality of grasp and the frequency and spontaneity of use of the affected limb.

It should also be considered, however, that caregivers have much more experience with (as well as a much greater understanding of) their children's capabilities. The camp counselors were aware of the ultimate goal of the intervention; as such, they may have unintentionally exaggerated any improvements that were observed. Caregivers, on the other hand, have the greatest knowledge of their children's abilities, as they have the most experience observing and assisting them with self-care tasks and other daily functional activities. Caregivers also interact with and receive feedback from the children's teachers at school, in addition to observing their children in the context of physical or occupational therapy, community-based activities, and during play. As a result of this extensive experience, parents have a more complete picture to reference, and thus a much better context within which to report any functional improvements. In all, the observation suggests that this potential discrepancy should be further investigated in future studies; for example, if there are two caregivers in the family, it may be beneficial to administer the assessments to both caregivers in order to compare the responses.

Another possible explanation for the observed differences in caregiver and camp counselor responses is the issue of learned helplessness (Maier & Seligman, 1976), which has been previously described in the context of developmental disabilities in the pediatric population (Weisz, 1982; Basil, 1992; Sloper & Turner, 1993). The theory of learned helplessness posits that an individual's experience with uncontrollable events can lead to the expectation that the individual has no control over future outcomes (Maier & Seligman, 1976). This expectation of no control leads to decreased motivation, sadness, and lowered self-esteem, which are collectively known as learned helplessness (Maier & Seligman, 1976). It has been suggested that children with motor impairments may be at risk of developing learned helplessness if their development of independence is not supported and encouraged (Henderson, Skelton, & Rosenbaum, 2008). Though parents may not intentionally impede the development of independence of the child, certain parental behaviours may promote learned helplessness in children with CP. For example, consistent and complete assistance in performing daily tasks, as well as providing insufficient motivation for independent task accomplishment, are factors that may contribute to the development of learned helplessness. The concept of learned helplessness may help explain the differences observed between camp counselor and caregiver responses on the performance section of the CTC questionnaire; while caregivers did not report a significant increase in performance on any of the measures, the average counselor reported significant increases in performance on all of the measures. It is possible that the participants had developed learned helplessness within the confines of the home environment, but when placed in an environment where assistance was not as readily offered, the children were required to act more independently. If this were the case, then it is possible that the counselors would observe an increase in performance while the caregivers would not.

The second finding involved caregivers consistently rating the participants at a higher initial level of function than the average counselor. Again, this difference could reflect the caregiver's more intimate knowledge of the child's capabilities, especially with regards to tasks such as feeding, toileting, and dressing. It could, however, indicate a potential bias in the caregiver responses; caregivers may be more reluctant to give their child a low score, whereas a camp counselor may be able to assess the child's function in a more impartial way. Despite the fact that camp counselors had limited exposure to the children after only one day of camp, they were specifically oriented towards use of the affected limb for 7 consecutive hours prior to assessing each child; this could be considered to be beneficial, as no outside experiences influenced the counselors' ratings of each child's initial performance.

Future research should consider administering assessments to both caregivers of a child, when possible; this would allow researchers to obtain a second evaluation of the child's initial level of function, while avoiding the potential bias of a camp counselor's rating who is involved in the therapy's administration. It would further allow researchers to investigate the possibility that children display different levels of independence when placed in different environments or when placed under different supervision. Participants may also behave differently depending on the home environment in which they live; the home environment itself depends upon multiple factors, including parental values, beliefs, and number of siblings. Differences in levels of motivation, assistance provided, and encouragement of independence may also exist between participants, and may also exist between caregivers. These differences in environmental and personal factors should be considered in future studies, and underline the importance of considering the modified CIMT intervention in the context of the WHO-ICF (WHO, 2001).

WHO-ICF

The WHO-ICF considers individual, environmental, and societal perspectives when discussing disability; when planning and implementing treatment techniques, various factors must be considered. In addition to body functions and structures, the individual's current level of ability and participation, as well as his or her home and community environments must be taken into account (WHO, 2001). Rather than focusing on repairing impairments in children with CP, the ICF model guides researchers to plan and implement interventions that will promote functional activity and full participation in daily life activities (Rosenbaum & Stewart, 2004). Ultimately, the goal of implementing a modified CIMT intervention is to improve each child's capacity to perform daily activities using the affected limb; in the current study, these skills were intentionally practiced in a natural setting in order to facilitate the transfer of these skills to daily life (Rostami & Malamini, 2012). Improvements that were observed in skills such as independence in self-care tasks may ultimately improve the child's participation in those activities. Improved social skills were reported by caregivers following the intervention in the current study; the enjoyable atmosphere of the day camp may have been beneficial in this respect. Though the children were undergoing a form of treatment, they were also engaged in fun activities while at camp, and had the opportunity to interact with other children who were facing similar challenges. The WHO-ICF considers these environmental and personal factors important within the context of implementing a treatment program for children with CP; although all children did not experience the same benefits following the CIMT intervention, not all children experienced difficulties in the same areas. In accordance with the personal and contextual factors outlined by the WHO-ICF, then, differences in areas of improvement can be reasonably expected within a heterogeneous sample such as this. Though the benefits varied within our sample, all children experienced some improvement in functional outcome. If participants are better able to perform activities in even one area of function, then they may participate in that activity more frequently; increased participation in various daily activities can lead to various developmental gains, such as improved social skills (as was observed in the current study). Developmental gains may then transfer to school, home and social environments, which would only further improve the child's functional status.

The personal factors of each child are particularly relevant to the current study, as each child's experience at home and in his or her social environment is a unique experience. Each child will have a different temperament, personality, and social life, all of which may affect participation during camp as well as motivation to practice any learned skills outside of camp. Each child will equally have different family structures, and each family will likely provide different levels of motivation and exhibit different beliefs, all of which may affect the way in which caregivers respond on assessment questionnaires. In addition, different family structures and levels of motivation affect the child's current situation with respect to his or her health condition and current state of functioning (WHO, 2001). For example, the PEDI is an assessment that measures various aspects of the child's independence when performing daily tasks; depending on how much independence is encouraged when performing such tasks, parents may have provided different responses on this questionnaire. During the initial intake appointment, caregivers were asked to rate, on a scale of 1-10, the level of encouragement that their children were given to use the affected arm at home (see Table 7). This large variability in levels of encouragement provided to use the affected arm at home may have contributed to the overall level of improvement of each child between the first and final assessments.

Statistical Versus Clinical Significance: Individual Differences

Although several of the primary motor assessments did not reach statistical significance, many of the measures yielded important clinical outcomes as a result of the intervention. For example, when asked about their satisfaction with their child's overall function on the CTC questionnaire, at least 50% of the parents reported increased satisfaction at the 3-month follow-up on 6/7 measures (Table 6). In addition, 83.3% of the parents reported increased satisfaction with respect to their child's spontaneity of use of the affected limb. This indicates that important clinical changes are being observed, as caregivers are reporting increased satisfaction in a variety of functional areas. Since the ultimate objective of the current study was to promote functional benefits for this population as a result of a modified CIMT intervention, these parental reports are important and should not be ignored. Several explanations are possible for the lack of statistically significant results, including small sample size, effects of dosage, varying levels of impairment, and heterogeneity of the sample; in the current study, the limited sample size and the heterogeneity within the sample are the most likely explanations for the lack of statistically significant results on certain measures. This study's results outline the particular importance of considering the WHO-ICF's personal factors of each child that have the potential to influence the outcome of the therapy (WHO, 2001).

Gilmore et al. (2010) investigated children's opinions of a CIMT intervention that took place in a day camp setting; an important finding was that children expressed frustration and discomfort about wearing the glove, and further identified the considerable level of effort required to persist with the CIMT intervention. This is a relevant finding, as frustration and large amounts of required effort may negatively affect the level of motivation of the children; this may lead to a decrease in their level of participation during camp or in the amount of effort they put forth during assessment sessions. If the children feel discouraged and participate less, then they are less likely to benefit from the camp activities which are specifically designed to improve the use of the affected upper limb. The study by Gilmore et al. (2010) suggests that decreased motivation in certain participants may help explain, at least in part, the reasons behind the varying results obtained on the standardized motor assessments.

A second possible explanation for the variability in the results is the differing levels of impairment experienced by each child; since each participant had a different level of impairment and possessed his or her own unique challenges (Table 1), it is conceivable that fewer statistically significant improvements may be observed on the standardized tests due to this variability within the sample. For example, participants 5 and 6 experienced the mildest upper-limb impairments; as such, their initial motor assessment scores were fairly high, leaving minimal room for improvement. Participant 3, on the other hand, experienced moderate upper-limb impairment in conjunction with multiple additional impairments; this participant demonstrated the most overall improvement, which supports the findings of Cope et al. (2010) suggesting that children with spastic hemiplegic CP displaying moderate impairments may benefit most from a CIMT intervention. With a limited sample size, this amount of variability renders it difficult to compare group means. Participants exhibited varying levels of upper-limb impairment, as well as a wide range of additional impairments, ranging from none at all to significant learning disabilities as well as one participant with a suspected autism spectrum disorder due to his associated impairments (Table 1). These individual differences likely had an effect on the overall outcome for each participant, again making group means difficult to assess, and further underlining the importance of considering the personal factors of the WHO-ICF when employing a motor intervention in children with CP. When each participant was used as his or her own control, however, many meaningful and practical changes were observed. This outlines the importance of considering important clinical changes in this population as opposed to exclusively examining statistically significant changes in group means; this is particularly important when examining interventions for children with spastic hemiplegic CP, as a large amount of variability exists within this population (Bax et al., 2006).

Conclusion and Suggestions for Future Research

The current study supports the effectiveness of a modified form of CIMT in inducing lasting functional benefits for children with spastic hemiplegic CP. Such functional benefits included improvements in grasping, protective extension, and the amount and quality of use of the affected limb; many of the gains that were made were maintained at the 3-month follow-up. This intervention, considered within the context of the WHO-ICF model, improved the activity and participation levels of participants. Future studies should use a control group, and should attempt to recruit larger sample sizes of children within a narrow age range, such as the range used in the current study; a larger sample size would further allow for analyses based on impairment level and other individual characteristics. Future studies should also consider the importance of an unbiased third party rating of the child's performance throughout the study, as it is possible that one caregiver's rating alone does not accurately reflect the entirety of the child's ability; factors such as parental motivation and level of assistance may influence the parent's perception of the child's independence and ability to perform a variety of tasks.

The implementation of modified CIMT in a day camp setting induced functional changes that persisted at the 3-month follow-up. Future studies should also incorporate imaging techniques, such as functional Magnetic Resonance Imaging, to investigate any possible cortical changes that may occur in conjunction with functional changes following modified CIMT. Future studies should further consider examining the potential benefits of combining therapeutic techniques; for example, Botulinum toxin A (Botox-A) is a pharmacological treatment that is commonly used for the management of the spasticity observed in CP (Graham et al., 2000; Bjornson et al., 2007). Botox-A focally decreases spasticity by reducing muscle contraction, which helps to prevent the development of muscle contractures (Borodic, Ferrante, Pearce, & Smith, 2004). Several studies have examined the combined effects of Botox-A and occupational therapy in children with spastic hemiplegic CP (Speth, Leffers, Janssen-Potten, & Vles, 2005; Lowe, Novak, & Cusick, 2006; Wallen, O'Flaherty, & Waugh, 2007); future research should investigate the potential benefits that may be derived from the combination of CIMT and Botox-A in this population. If motor interventions alone can induce lasting functional benefits for children with hemiplegic CP, then it is possible that the combined effects of pharmacological and motor interventions may yield even greater functional outcomes for children in this population.

Over the course of the current motor intervention, several lasting statistically and clinically significant improvements were observed in a variety of areas; improvements were observed on both standardized motor assessments and caregiver reports. Future studies employing CIMT should consider the importance of applying such techniques in a natural environment; the day camp model in the current study was demonstrated to be both an effective and economically efficient setting in which to intervene for children with spastic hemiplegic CP.

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SECTION 4: MANUSCRIPT 2

THE CHILD-THERAPIST INTERACTION: A POSSIBLE INFLUENCE ON THE OUTCOME OF CONSTRAINT-INDUCED MOVEMENT THERAPY IN CHILDREN WITH CEREBRAL PALSY

Abstract

Constraint-induced movement therapy (CIMT) is a form of therapy for children with spastic hemiplegic cerebral palsy (CP) that has yielded inconsistent results in the literature. The current study's objective was to examine the potential contribution of the child-therapist (C-T) interaction during the assessment sessions as a factor influencing the child's scores on tests of motor performance. CIMT was administered in the context of a day camp for children aged 5-9 years with a diagnosis of spastic hemiplegic CP. Participants were assessed prior to camp, immediately following camp, and three months later. All assessment sessions were videotaped and scored using the Therapy Process Observational Coding System – Alliance scale (TPOCS-A) in order to quantify the strength of the C-T alliance. Correlation analyses were performed on TPOCS-A scores and scores of motor performance. Results demonstrated that the strength of the C-T interaction was significantly and positively correlated with total Quality of Upper Extremity Skills Test (QUEST) scores ($p<0.05$), grip strength in the affected arm ($p=0.05$), and on scores of social function provided by caregivers on the Pediatric Evaluation of Disability Inventory (PEDI; $p<0.05$). This suggests that the C-T interaction may be an important contributor to a participant's performance during the assessment session, and may ultimately affect his or her scores on tests of motor performance. Previous research has not formally measured this interaction, which may explain some of the inconsistencies observed in the rehabilitation literature when employing CIMT in this population. Future studies should attempt to maximize the C-T interaction in order to obtain results that reflect the true effects of CIMT in this population.

Cerebral Palsy

Cerebral palsy (CP) results from a permanent and non-progressive abnormality that occurs in the fetal or infant brain (Bax, Tydeman, & Flodmark, 2006); the pathologies observed in children diagnosed with CP include, but are not limited to, perinatal stroke, lesion to the middle cerebral artery, or acute damage to sub-cortical structures (Azzopardi et al., 1999; Cowan et al., 2003). Though modern imaging techniques have allowed researchers to investigate the origins of the abnormalities, the causes of CP remain unknown (Cowan et al., 2003; Robinson et al., 2009). CP represents the most common pediatric physical disability, occurring on average in 1 out of 500 children (Stanley, Blair, & Alberman, 2000; Reid, Carlin & Reddihough, 2011); as such, the study and the treatment of CP are both relevant and important (Blair & Watson, 2006). Spastic hemiplegic CP occurs in one third of those diagnosed, and is the most common form of CP; this type of CP is characterized by rigid movements as well as asymmetric motor impairment (Hagberg, Hagberg, Beckung, & Uvebrant, 2001; Platt et al., 2007; Reid et al., 2011).

In hemiplegia, one side of the body is more impaired than the other; the upper limb is typically more affected than the lower limb, and the impairments compromise the child’s ability to perform gross motor tasks as well as fine manipulation tasks. Skills such as reaching, grasping, and releasing and manipulating objects are challenging for children with spastic hemiplegic CP (Sakzewski, Ziviani & Boyd, 2009). These areas of difficulty, in conjunction with challenges in the areas of independence, self-care, play, and overall daily function are observed in children with hemiplegic CP. The functional limitations that occur in hemiplegic CP ultimately interfere with proper motor development in various ways, rendering everyday tasks and overall independence a challenge for children in this population (Brady & Garcia, 2009).

Interventions for Children with CP

Movement interventions for children with CP are based in the knowledge that the human brain has the capacity to reorganize itself by forming and maintaining new connections (Nudo, Wise, SiFuentes, Milliken, & Garrett, 1996; Levin, 2003; Schaechter, 2004). The formation of these new connections is activity-dependent and is termed neuroplasticity; neuroplasticity has been shown to be more effective in the developing brain, and can manifest itself in newly acquired or modified motor behaviours (Taub, DeLuca, Ramey, & Echols, 2004; Sutcliffe, Gaetz, Logan, Cheyne, & Fehlings, 2007). Thus, it follows that children may benefit most from an early intervention program aimed to induce cortical reorganization and motor gains. The most commonly employed motor therapies for treating individuals with CP are delivered by physical therapists and occupational therapists (OTs), and include neurodevelopmental therapy (NDT) techniques (Boyd, Morris, & Graham, 2001). Effective treatment methods for the upper limb impairment observed in CP are needed; constraint-induced movement therapy (CIMT) is a relatively new movement-based intervention that demonstrates promise in this respect (Boyd et al., 2001).

CIMT is a form of rehabilitative therapy used in children with spastic hemiplegic CP (Huang, Fetters, Hale & McBride, 2009; Cope et al., 2010). It involves constraining the less affected limb, while simultaneously training the more affected limb (Taub & Crago, 1998). The originally proposed recommendations for employing CIMT as a therapeutic technique were to restrain the less-affected limb for 90% of the individual's waking hours, and to perform intensive movement therapy with a trained therapist for six hours per day over a two-week period (Taub, Crago, & Uswatte, 1998). However, several studies have demonstrated the effectiveness of a modified form of CIMT, wherein the hours of restraint, and/or the hours of limb training are reduced; these studies demonstrate CIMT's ability to increase the child's spontaneous use of the affected limb in day-to-day tasks and self-care activities (e.g. dressing, feeding, and toileting; Charles & Gordon, 2007; Cope et al., 2010), as well as its ability to improve motor performance as measured by standardized motor assessments (Taub et al., 2004; DeLuca, Echols, Taub, & Ramey 2006). In many studies, these improvements last for months (Taub et al., 2004; Bonnier, Eliasson, & Krumlinde-Sundholm, 2006; Charles & Gordon, 2007; Cope et al., 2010). In addition, several studies have yielded successful results when employing modified forms of CIMT in alternative settings, such as at home, at school, and in community settings, such as during a day camp (Bonnier et al., 2006; Aarts, Jongerius, Geerdink, van Limbeek & Geurts, 2010; Cope et al., 2010; Taub et al., 2011).

Though previous studies have reported many positive findings, some inconsistencies have been reported with respect to the extent of the benefits observed following CIMT in children with CP (Hoare, Imms, Carey, & Wasiak, 2007; Wolf, 2007; Huang et al., 2009). While some have yielded positive outcomes for all participants who receive CIMT (Taub et al., 2004; Bonnier et al., 2006; DeLuca et al., 2006; Al-Oraibi & Eliasson, 2011), others have yielded positive outcomes for only some participants (Charles, Lavinder, & Gordon, 2001; Cope et al., 2010; Eliasson, Shaw, Berg, & Krumlinde-Sundholm, 2011), and still others have found positive results only on certain measures (Aarts et al., 2010; Aarts, Jongerius, Geerdink, van Limbeek, & Geurts, 2011;

Chen et al., 2012). As such, more research into the possible factors that influence the results, and consequently the perceived outcome of CIMT, is needed; a greater understanding of these factors will allow researchers to better understand the benefits of modified CIMT for children with spastic hemiplegic CP. One possible influential factor involves the interaction – or alliance – between the child and the therapist performing the assessments.

Therapeutic Alliance: Importance for Therapeutic Outcome

Therapeutic alliance is a concept that dates back to the work of Anna Freud; more than 60 years ago, Freud acknowledged that an "affectionate attachment" between the child and therapist was a "prerequisite for all later work" in child therapy (Freud, 1946, p. 31). This observation separates the child-therapist (C-T) interaction into two components; these components are still commonly referred to in the current literature. The first component described is the bond that exists between the child and the therapist, and the second involves the task(s) to be accomplished throughout the rehabilitative process (McLeod & Weisz, 2005). Although the client-therapist interaction has been studied extensively in the adult population, the relationship between the child and the therapist has only recently begun to be investigated in the context of scientific research (Shirk, Karver, & Brown, 2011).

Research in the area of adult therapist alliance has demonstrated that alliance is a consistent predictor of successful therapy outcomes (Horvath & Symonds, 1991). This is presumably because a productive relationship between the therapist and the client fosters an understanding of the reasons for the intervention; it may also motivate the client to perform the required tasks during the therapy and assessment sessions in order to experience a successful outcome from the treatment. If the client trusts the therapist, which is paramount in a beneficial therapeutic relationship, then he or she is more likely to believe that the rehabilitative procedures merit effort and commitment (McLeod & Weisz, 2005). As such, adults may be more likely to demonstrate their best efforts during assessment sessions; this would allow the therapist to accurately assess the adult's progress, and modify the therapy in order to produce the most beneficial outcomes for the adult. Because children are often in therapy as a result of the parent/guardian's understanding of its benefits, and may lack the cognitive capabilities to understand these concepts in the same way that adults do, the situation involving the C-T alliance must be examined under different pretenses (McLeod & Weisz, 2005). It has been noted that the link between the C-T alliance and treatment outcome is inconclusive; for this reason, research in this area is needed (McLeod & Weisz, 2005).

Alliance in Child Therapy

Children may have difficulty understanding the reasons for which they are enrolled in therapy; similarly, they may not fully comprehend the therapeutic goals or the context and methods of the therapeutic process (McLeod & Weisz, 2005). As such, it is imperative that certain developmental considerations are taken into account when children are the clients of a rehabilitative intervention. McLeod and Weisz (2005) discuss the two components of the interaction that are particularly important in the C-T alliance: bond, which refers to the affective aspects of the relationship, including facial expressions, body language, and overall emotional connection between the therapist and the child, and task, which refers to participation in the therapeutic activities. These authors also underline the importance of direct observation by an unbiased third party in the analysis of the C-T alliance; this component is imperative, as self-report measures are often unreliable, due to developmental limitations of children and a sense of social pressure that parents may feel to say something positive about the therapist.

The therapist's ability to develop a warm relationship (bond) and engage the child in the therapeutic process (task) is believed to be crucial to the success of the therapy (McLeod & Weisz, 2005). However, children may develop a relationship with the therapist for a number of reasons; one example of this was postulated by Anna Freud, who noted that the child may feel a certain need being fulfilled by the therapist that is not fulfilled elsewhere: "If no one at home plays games with the child, for example, he might like to come to treatment because there a grown-up pays attention to him" (Freud, 1946, p.31). As such, the relationship between a child and a therapist may not be as cognitively consensual as the relationship between an adult and a therapist; this is likely due to the child's limitations in comprehension of the therapy's purpose, and may hinder the development of a strong C-T alliance. Similarly, difficulties exist in the 'task' area of the alliance; 'task' refers specifically to the ways in which the therapist engages the child in therapeutic activities. Whereas adults and their therapists can agree upon certain goals and expected outcomes, children may not be able to link therapeutic activities with desired outcomes. Specifically, children may not understand why they are asked to perform tasks repetitively, particularly if those tasks are challenging for them. These factors may affect the effort that children put forth in therapy sessions, and may also affect their motivation to do 'homework' between sessions, both of which would have an effect on the results of a motor intervention in children with CP.

Examining the Child-Therapist Interaction

If a child is not inclined to perform to the best of his or her ability during an assessment session (due to personality, lack of motivation, etc.), an accurate reflection of the therapy's results – whether successful or unsuccessful – may not be obtained from analyzing the results from the motor assessments that took place during that session. In order to address this potential issue, the current study sought to examine the C-T interaction as a possible factor influencing the perceived outcome of a modified CIMT intervention in children with hemiplegic CP. It has been previously demonstrated that the interaction, or alliance, between the child and the therapist may influence the success of the therapy (McLeod & Weisz, 2005; Liber et al., 2010; Shirk et al., 2011). For this reason, it was our intention to analyze this relationship in the context of a CIMT intervention in order to gain a better understanding of its potential influence on the treatment outcomes reported in the literature for in this population. Specifically, the way in which the child interacts with the therapist may affect how accurately the measurements are able to be made on the assessments. For example, if the child is not engaged by the therapist, then he or she may not perform the tasks to the best of his or her ability, which would compromise both the accuracy and the validity of the assessment scores. Examining the C-T alliance by videotaping and systematically coding the assessment sessions will allow the researchers to determine if the alliance between the child and therapist affects the child's performance on the assessment measures; this aspect of the current study is unique, and has not been examined in previous research using CIMT in individuals with CP.

In order to assess the C-T interaction and determine its potential influence on the perceived outcomes of CIMT, the Therapy Process Observational Coding System – Alliance (TPOCS-A; McLeod, 2005) was used. Several studies have been performed that have videotaped assessment sessions and subsequently used the TPOCS-A scale to assess the C-T interaction (McLeod & Weisz, 2005; Chiu et al., 2009; Liber et al., 2010; Shirk et al., 2011). McLeod and Weisz (2005) conducted a study in which 22 children (mean age = 10 years, 3 months) with anxiety and depressive disorders had their therapy sessions coded using the TPOCS-A scale. The authors hypothesized that a strong C-T and parent-therapist alliance would yield a more successful treatment outcome in this population. The results demonstrated that both the C-T alliance and the parent-therapist alliance were positively related to youth treatment outcomes (symptomatology in this case); however, the C-T and parent-therapist alliances were found to be independent of one another (McLeod & Weisz, 2005). This suggests that the child and therapist can experience a relationship that is independent of the parent's feelings towards the therapist or the therapy session. Another group of authors used the TPOCS-A scale to analyze the C-T alliance in 34 children aged 6-13 years (mean age = 9 years, 9 months) with a diagnosis of an anxiety disorder; this study examined the C-T alliance before, during, and following a cognitive-behavioural therapy intervention (Chiu, McLeod, Har, & Wood, 2009). The results of the study demonstrated that improvement in the C-T alliance over the course of the therapy predicted better post-treatment outcomes. The results further suggested that a strong C-T alliance assessed early in treatment was associated with a decrease in symptomatology at mid-treatment, and higher treatment satisfaction at post-treatment (Chiu et al., 2009). From these results, it seems that a strong C-T alliance may promote successful therapeutic outcomes. In fact, a strong C-T alliance may be needed to maximize treatment outcomes in children; this was investigated in the current study in children with a diagnosis of spastic hemiplegic CP.

World Health Organization: International Classification of Functioning, Disability and Health (WHO-ICF)

The WHO-ICF is an internationally accepted framework that classifies disability based on body, individual and societal perspectives; body functions and structures are considered, as are the domains of activity and participation (WHO, 2001). The ICF further acknowledges the importance of contextual factors in the analysis of disability, and thus also considers environmental and personal factors in its model (WHO, 2001). By shifting the focus from cause to impact, the ICF has become an important model that seeks to place all forms of disability on a similar platform where they can be reasonably compared. The goal of implementing a CIMT intervention is to improve each child's capacity to perform daily activities such as self-care tasks and independent mobility, which would hopefully improve the child's everyday participation in those activities outside of therapy. The personal factors of each child are also considered in the WHO-ICF model, as these factors affect activity and participation; personal factors include things like age, personality, and temperament. Additional personal factors include the family structure, school and social environments of the participants; the personal factors of each child are particularly relevant to the current study, as examining a child's interaction with the acting therapist is a unique experience. Each child will have a different temperament, personality, and family life, all of which will influence the interaction that occurs between the child and therapist.

Purpose

Previous research has reported varying results with respect to the benefits of implementing CIMT in the pediatric population affected by CP (Hoare et al., 2007; Wolf, 2007; Huang et al., 2009). The primary purpose for the larger study conducted was to add to the existing scientific literature on the potential benefits of a modified form of CIMT in a day camp setting for children with spastic hemiplegic CP. The secondary purpose of the study was to address the inconsistency of the results obtained in this research area; these inconsistencies can likely be attributed to a number of factors, including varied methodology across studies, the application of a variety of assessment methods, and possible individual characteristics that may have an effect on the treatment outcome. In the current study, we hypothesized that one reason for the observed inconsistencies in studies using CIMT in this population is that there may be measurement errors in the assessments due to the influence of the C-T interaction. It is possible that the mixed results that have been observed when applying CIMT to this population have occurred in part due to overlooking this potentially important therapeutic relationship. In other words, if the child's performance during the assessment session is not reflective of his or her actual motor capabilities, the results of the study will not accurately reflect the therapy's effects.

In the present study, the C-T interaction was analyzed in the context of a CIMT intervention in children aged 5-9 years with a diagnosis of spastic hemiplegic CP; the C-T alliance was examined in this context in order to determine if there was an observable effect on the results obtained during the assessment sessions. Results obtained from this analysis may elucidate whether the client's individual experience and/or the collaborative C-T relationship influence the perceived treatment outcomes following a CIMT intervention in children with spastic hemiplegic CP, and may inform future research and clinical practice in this area.

Methods

Study Design

The current study involved a pre-assessment that took place one week prior to the intervention, a 9-day intervention during which all participants wore a splint on their less affected arm for 7 hours per day and participated in activities that promoted the use of the affected arm, a post-assessment that took place one week after the intervention's end, and a 3-month follow-up assessment.

Cast Camp

In the current study, six children (four males, two females) between the ages of 5 and 9 years with a diagnosis of spastic hemiplegic CP took part in modified CIMT that was administered in the context of a two-week day camp. Ethical approval was obtained from the University's Research Ethics Board as well as from the Ethics Committee at the Children's Treatment Centre (CTC). Parental consent and participant assent were received from all participants and their parents/guardians.

Participants were enrolled in a day camp that took place over a two-week period during the summer, for a total of 9 days; during camp hours (7 hours per day), each participant wore a splint on the less affected upper limb that prevented wrist flexion and extension, as well as grasping. The camp was led by three highly trained camp counselors who administered CIMT in the context of the day camp; all activities performed while at camp were selected specifically to promote the use of the affected limb. Several assessments were used in this study; some assessments aimed to directly assess the function of the affected hand, while others investigated the parents' perceptions of the children's function. All assessments were conducted by an OT who was not involved in Cast Camp in order to avoid any influential bias. The assessments took place on three separate occasions: one week prior to the camp's beginning, one week following the camp's end, and three months following the camp's end.

The assessments used in this study included the Quality of Upper Extremity Skills Test (QUEST; DeMatteo et al., 1993), the Pediatric Evaluation of Disability Inventory (PEDI; Haley, 1992), and a questionnaire developed by the CTC (CTC Questionnaire) based on the Canadian Occupational Performance Measure (Law et al., 1990). The QUEST (maximum possible score = 100 for each section) is a standardized assessment of motor performance that evaluates a child's 'all or nothing' ability to complete a variety of tasks, including upper limb movement, grasping and manipulating objects, and demonstrating balance and protective extension (DeMatteo et al., 1993). The PEDI (maximum possible scaled score = 100 for each section) is a questionnaire that is completed by the child's caregiver; it measures the ability of the child to participate in self-care tasks (e.g. dressing, feeding), mobility capabilities (e.g. indoor and outdoor movements), and social function abilities (e.g. communication and social play; Haley, 1992). The CTC Questionnaire (maximum possible score = 10 for each section) is also completed by the caregiver, and assesses any changes observed in the frequency and/or spontaneity of use of the affected limb; further, it assesses the child's ability to perform a variety of self-care tasks, and addresses both the parents' evaluations of the importance of the child improving in each area as well as their current levels of satisfaction with the child's performance of each task. Additional assessments included measures of range of motion (using a goniometer), grip strength (using a Baseline® sphygmomanometer), and assessment of spasticity and level of impairment using the Modified Ashworth Scale (Bohannon & Smith, 1987), the Gross Motor Functional Classification System (GMFCS; Rosenbaum, Palisano, Bartlett, Galuppi, & Russell, 2008), and the Manual Ability Classification System (MACS; Eliasson et al., 2006).

Videotaping of Assessment Sessions

In this study, all six children participated in three separate assessment sessions, which provided a total of 18 assessment session videotapes to be scored; all sessions were videotaped with a Sony® Handycam HDR-CX110. All assessment sessions were conducted by the same OT; this OT did not participate in the intervention in any way, and was not the primary OT for any of the participants. Further, the assessing OT did not know any of the participants prior to the study, and she did not have access to their medical records; the only time the OT interacted with the participants was during the actual assessment sessions.

TPOCS-A

Due to the relatively new application of the concepts of alliance to child therapy, Shirk et al. (2011) note that there is no 'gold standard' for measuring C-T as of yet; however, the TPOCS-A scale, developed by McLeod & Weisz (2005) has been used in several studies, and has been demonstrated to be a valid and reliable assessment of the C-T alliance (Chiu, McLeod, Har, & Wood, 2009; Shirk et al., 2011; Liber et al., 2010). The TPOCS-A scale was used in the current study to investigate the possible influence of the C-T interaction on the treatment outcome. The scale itself is composed of nine questions that investigate the interaction between the child and therapist during the assessment session; there are six questions addressing the affective aspects of the interaction (the 'bond'), and three questions addressing the participation in therapeutic activities (the 'task'; McLeod, 2005). Additionally, there are four questions that assess the quality of the assessment session as a whole by asking the rater questions regarding their specific like or dislike of both the client and the therapist for that particular session.

Results

Scoring of Assessment Sessions

All 18 assessment sessions were coded by the primary author using the TPOCS-A scale. As per the scoring protocol, the TPOCS-A total scale and quality of session scores were obtained by taking the sum of the item scores and dividing by the total number of items (ensuring that the scores for negatively worded answers were reversed; McLeod, 2005). The maximum total TPOCS-A scale score is 5.00, while the maximum quality of session score is 7.00. Two blind external raters were trained on TPOCS-A scoring protocol by the primary author, and then proceeded to code a sample of four assessment videos each (two of which were the same); interrater reliability was thus established for 22% of the videos (Table 8). Intrarater and interrater reliability were established using the intraclass correlation coefficient; for Intrarater reliability, the intraclass correlation coefficient was 0.985 ($p<0.001$).

Table 8: Summary of Inter-rater Reliability Analysis for a Sample of Assessment Videos Using the Intraclass Correlation Coefficient

Video Rated	Total number of raters	Intraclass correlation coefficient	*p* value
Participant 1 – Session 1	2	0.896	<0.001
Participant 3 – Session 1	3	0.915	<0.001
Participant 5 – Session 1	2	0.996	<0.001
Participant 2 – Session 2	2	0.993	<0.001
Participant 6 – Session 2	2	0.988	<0.001
Participant 4 – Session 3	3	0.939	<0.001

Analysis of C-T Interaction and Therapeutic Outcome

Correlation analysis using Pearson's *r* was performed for each child's TPOCS-A scores and his or her scores on tests of motor performance and functional assessments that took place during the assessment session. Correlations were performed between total TPOCS-A scale scores as well as overall quality of session scores and QUEST scores, PEDI scores, and grip strength scores (Table 9). All data handling and analyses were performed by the primary author; SPSS version 19.0 was used for computerized analyses (SPSS, Inc., Chicago, IL).

Table 9: (a) Scores by participant and assessment session on the QUEST and mean PEDI scores with standard deviation

Participant	Session	QUEST					PEDI					
		DM	Grasp	WB	PE	Total	Self-Care	Mobility	Social Function	Self-Care	Mobility	Social Function
1	PRE	70.31	69.57	92.00	60.00	72.97	68.3±1.8	63.9±1.7	64.6±1.7	74.5±4.7	74.5±4.7	57.9±3.5
	POST	62.50	78.26	74.00	75.00	72.44	NT	NT	NT	NT	NT	NT
	3MO	56.25	82.61	74.00	75.00	71.97	63.9±1.7	70.0±1.8	68.3±1.8	76.7±5.2	72.7±4.4	60.1±3.5
2	PRE	75.00	69.57	100.00	83.33	81.98	69.1±1.8	66.8±1.8	67.6±1.8	76.7±5.2	74.5±4.7	61.1±3.5
	POST	82.81	78.95	98.00	100.00	89.94	NT	NT	NT	NT	NT	NT
	3MO	76.56	73.68	88.00	100.00	84.56	70.0±1.8	70.0±1.8	69.1±1.8	100±0.0	74.5±4.7	61.1±3.5
3	PRE	70.31	60.87	98.00	50.00	69.80	58.0±1.6	67.6±1.8	66.0±1.7	55.7±3.5	72.7±4.4	53.4±3.6
	POST	67.19	65.22	74.00	66.67	68.27	NT	NT	NT	NT	NT	NT
	3MO	78.13	82.61	92.00	66.67	79.85	60.5±1.6	60.5±1.6	66.8±1.8	63.4±3.5	72.7±4.4	48.6±3.8
4	PRE	54.84	56.52	74.00	0.00	61.79	64.6±1.7	65.3±1.7	63.9±1.7	69.6±4.0	72.7±4.4	59.0±3.5
	POST	53.23	52.17	50.00	41.67	49.27	NT	NT	NT	NT	NT	NT
	3MO	51.56	47.37	0.00	41.67	46.87	65.3±1.7	65.3±1.7	64.6±1.7	89.7±10.3	71.1±4.1	59.0±3.5
5	PRE	93.75	82.61	100.00	91.67	92.01	72.6±2.0	63.9±1.7	70.0±1.8	83.2±7.2	69.6±4.0	60.1±3.5
	POST	100.00	82.61	100.00	100.00	95.65	NT	NT	NT	NT	NT	NT
	3MO	95.31	100.00	100.00	83.33	94.66	75.9±2.3	75.9±2.3	71.7±1.9	83.2±7.2	72.7±4.4	60.1±3.5
6	PRE	92.19	82.61	100.00	91.67	91.62	73.6±2.0	68.3±1.8	70.8±1.9	100±0.0	72.7±4.4	60.1±3.5
	POST	93.75	95.65	100.00	100.00	97.35	NT	NT	NT	NT	NT	NT
	3MO	96.88	100.00	100.00	100.00	99.22	79.0±2.8	79.0±2.8	71.7±1.9	64.5±3.6	59.0±3.5	62.2±3.5

DM=Dissociated Movements; WB = Weight Bearing; PE=Protective Extension; NT=Not Tested

(b) Scores on Grip strength measures and TPOCS-A scale

Participant	Session	Grip strength		TPOCS-A	
		Affected Limb	Unaffected Limb	Total Score	Quality of Session
1	PRE	1.83	4.83	3.50	5.25
	POST	1.00	4.33	1.63	4.50
	3MO	NT	NT	1.13	4.50
2	PRE	0.67	4.50	4.38	7.00
	POST	0	3.83	4.75	7.00
	3MO	1.17	5.17	4.63	6.50
3	PRE	0.33	2.17	3.13	5.5
	POST	1.33	3.83	1.88	5.75
	3MO	1.75	3.67	2.88	6.5
4	PRE	NT	4.08	0.88	3.75
	POST	0	4.00	0.25	3.50
	3MO	0.17	4.33	0.38	4.00
5	PRE	2.50	4.83	4.75	7.00
	POST	2.17	4.00	4.13	6.75
	3MO	2.50	3.83	5.00	6.75
6	PRE	3.00	4.67	4.50	6.75
	POST	2.83	5.50	4.75	7.00
	3MO	3.00	5.67	5.00	7.00

NT=Not Tested

TPOCS-A and QUEST Scores

The participants’ total TPOCS-A scores were positively correlated with the total QUEST scores at the pre-assessment session (*r*(6)=0.91, *p*=0.01), the post-assessment session (*r*(6)=0.97, *p*<0.01), and at the 3-month follow-up session (*r*(6)=0.93, *p*<0.01; see Appendix 9). Participants who had a weaker C-T interaction with the therapist during the assessment sessions consistently scored lower on the QUEST. In addition, a statistically significant positive correlation was found between the total TPOCS-A score and each individual section of the QUEST at the pre-assessment and post-assessment sessions, and for three out of four of the sections at the 3-month follow-up (see Table 10). Only the Grasps sub-section of the QUEST did not reach statistical significance at the 3-month follow-up; however, the *r* value was 0.75, and the *p* value (*p*=0.09) as well as the graphical relationship demonstrate a trend towards significance (Appendix 10). The TPOCS-A quality of session scores, which provide an additional rating for each session, were found to be positively and significantly correlated with total QUEST scores at the pre-assessment (*r*(6)=0.967, *p*<0.01), the post-assessment (*r*(6)=0.929, *p*<0.01), and the 3-month follow-up sessions (r(6)=0.916, p=0.01; Appendix 11).

Table 10: Correlations between TPOCS-A Scores and Individual Sub-Sections of QUEST at each Assessment Session.

QUEST Sub-Section	Session	Pearson's *r* (correlation with TPOCS-A score)	*p* value
Dissociated Movements	PRE	$r(6)=0.895$	$p=0.02$*
	POST	$r(6)=0.918$	$p=0.01$*
	3MO	$r(6)=0.940$	$p<0.01$*
Grasps	PRE	$r(6)=0.859$	$p=0.03$*
	POST	$r(6)=0.851$	$p=0.03$*
	3MO	$r(6)=0.746$	$p=0.09$
Weight Bearing	PRE	$r(6)=0.944$	$p<0.01$*
	POST	$r(6)=0.978$	$p<0.01$*
	3MO	$r(6)=0.810$	$p=0.05$*
Protective Extension	PRE	$r(6)=0.996$	$p<0.01$*
	POST	$r(6)=0.968$	$p<0.01$*
	3MO	$r(6)=0.853$	$p=0.03$*

* indicates statistical significance, $\alpha=0.05$

TPOCS-A and PEDI Scores

A positive and statistically significant correlation was found between total TPOCS-A scores and participants' social function scores provided by caregivers on the PEDI at the pre-assessment ($r(6)=0.814$, $p<0.05$) and at the 3-month follow-up assessment ($r(6)=0.857$, $p=0.03$; Appendix 12). A significant positive correlation was also found between the TPOCS-A score for quality of session and the social function score provided by caregivers on the PEDI at the pre-assessment ($r(6)=0.867$, $p=0.03$). Correlations were further observed between total QUEST scores and social function scores as measured by the PEDI at the pre-assessment ($r=0.96$, $p<0.01$) and the 3-month follow-up (r=0.93, p<0.01); children with higher social function scores obtained a higher total QUEST score on both assessment occasions.

TPOCS-A and Grip Strength

No significant correlations were found between the TPOCS-A scores and the grip strength scores for either the affected or the unaffected arm at any of the assessment sessions. However, participant 2's scores were extreme outliers; this participant obtained low grip strength scores for the affected limb, despite the effort that he appeared to put forth in other areas of the session (see Table 10b). As such, participant 2's scores were excluded from the correlational analyses for grip strength; when excluded, statistically significant correlations between TPOCS-A total score and grip strength in the unaffected arm were found at the pre-assessment (r(6)=0.88, p=0.05), the post-assessment (r(6)=0.99, p<0.01), and at the 3-month follow-up (r(6)=0.98, p=0.02; Appendix 13). It was further found that the TPOCS-A quality of session scores were positively correlated with grip strength scores at the post-assessment (r(6)=0.97, p<0.01) and at the 3-month follow-up (r(6)=0.96, p=0.04) when participant 2's scores were excluded; the scores at the pre-assessment were not significant (r(6)=0.85, p=0.065), though there was a trend towards a positive correlation (Appendix 14).

Discussion

Previous research has reported inconsistent benefits and functional outcomes when applying modified CIMT in the pediatric population with CP (Hoare et al., 2007; Wolf, 2007; Huang et al., 2009). Many authors have suggested that the personal factors of participants should be considered, and that CIMT should not be applied indiscriminately to all individuals within this population until these factors are established (Lavinder, Taub, & Gentile, 1998; Charles, Wolf, Schneider, & Gordon, 2006; Cope et al., 2010; Case-Smith, DeLuca, Stevenson, & Ramey, 2012; Wang et al., 2013). In the present study, it was hypothesized that one potential reason for these inconsistencies is that accurate measurement of a child's true motor abilities during an assessment session depends upon the strength of the interaction between the child and the acting therapist during each assessment session. In other words, if there is a weak bond between the child and the therapist (i.e. a poor C-T interaction), then the child may not perform to the best of his or her ability during the assessment session. If this is the case, then children with weaker C-T interactions may score lower on the motor assessments that are administered during the assessment sessions; however, these scores are not necessarily an accurate reflection of their true motor abilities. Ultimately, if the C-T interaction significantly affects participants' scores on motor assessments during the assessment sessions, then the success or failure of the intervention itself cannot accurately be measured without taking the C-T alliance into account. If the C-T alliance influences the scores on motor assessments at any of the three assessment sessions, this will have an effect on the perceived outcomes of the intervention.

It was found in the current study that the strength of the C-T interaction did, in fact, influence the scores that participants achieved on the standardized motor assessment (QUEST) at all three assessment times. Specifically, participants who had a stronger C-T alliance obtained a higher total QUEST score on all three assessment occasions. Participants whose assessment sessions had a higher "quality of session" as measured by the TPOCS-A also scored higher on the motor assessments that were taken during the assessment session. The quality of session section of the TPOCS-A consists of four questions, and requires coders to evaluate the therapist, the child, and the session as a whole in order to obtain a global rating for that session. The finding that positive correlations were observed between both the TPOCS-A total score and QUEST scores and the TPOCS-A quality of session score and QUEST scores supports the hypothesis that the C-T interaction has an influence on the results of the motor assessments.

Liber et al. (2010) examined alliance in the context of cognitive behavioural therapy (CBT) for youth diagnosed with anxiety disorders, since after receiving CBT, 20-60% of youth still meet the criteria for an anxiety disorder (Cartwright-Hatton, Roberts, Chitsabesan, Fothergill, & Harrington, 2004; In-Albon & Schneider, 2007). In other words, the results of CBT for youth with anxiety disorders demonstrates that the intervention is not effective for all children who receive it; the authors thought that the C-T alliance may be a contributing factor to the outcome of the therapy (Liber et al., 2010). This research question likens the rationale of the study by Liber and colleagues (2010) to that of the current study, which was also investigating the C-T alliance as a potential contributing factor to the perceived outcomes of the therapy. Liber et al. (2010) presented two important findings that are particularly relevant: first, it was found that a strong alliance may be more important in predicting the outcome of one-on-one therapy versus group therapy. This is important for studies using a CIMT intervention in children with CP, as the assessment sessions are generally performed in a one-on-one setting, which was the case in this study. Second, Liber et al. (2010) found that the influence of the C-T interaction on the outcome of treatment may be stronger in individuals with less severe psychological disorders. This suggests that the influence of the C-T alliance, and thus the investigation of this interaction, may be more useful in cases where the children being examined have less severe psychological impairments. This finding is also relevant to the current study, as the TPOCS-A had not been used in children with hemiplegic CP prior to this study; this assessment may be ideal for use in this population to examine the C-T relationship because the majority of children with hemiplegic CP do not have severe psychological impairments (Goodman & Graham, 1996; Parkes et al., 2008). Goodman and Graham (1996) studied 149 children with hemiplegic CP intensively, and found that about half of those studied experienced some psychological disturbances; however, the majority of these disturbances included irritability, anxieties and fears. Behaviours that are more indicative of severe psychological impairment, such as deliberately antisocial behaviours and depression, were uncommon (Goodman & Graham, 1996).

Taken together, these results suggest that the C-T interaction is an important factor that must be considered when interventions such as modified CIMT are employed in this population; the results further suggest that the strength of the C-T interaction may contribute to the inconsistencies observed when employing CIMT in this population. Although several of the primary motor assessments yielded important clinical outcomes as a result of the intervention, many of the measures did not reach statistical significance (see Manuscript 1). Several explanations are possible for the lack of statistically significant results, including small sample size, effects of dosage, and varying levels of impairment; however, the results found in the current study demonstrate that the contribution of the C-T interaction may be an important factor to consider in this respect. In other words, if a therapist does not measure statistically significant improvements following the intervention, this may not mean that improvements did not occur; rather, it is possible that the absence of a strong C-T alliance during the assessment session masked potentially important improvements. If a child's true motor ability is not accurately measured during the assessment sessions due to a weak C-T interaction, then a conclusive description of the intervention's success cannot be established. Since the C-T interaction was significantly related to the total scores obtained on the QUEST by the participants in this study, future research employing CIMT should consider the importance of maximizing this alliance in order to obtain optimal and accurate measurements of each child's ability following the intervention. Taking the appropriate steps towards ensuring that participants' true motor capabilities are captured will ensure a more accurate evaluation of the effectiveness of the therapy.

In addition to the statistically significant correlations found between TPOCS-A total scores and QUEST total scores, statistically significant positive correlations were also found between TPOCS-A total scores and each sub-section of the QUEST at the first and second assessment sessions (Table 10). At the 3-month follow-up session, the Dissociated Movements, Weight Bearing, and Protective Extension sub-sections had correlations that reached statistical significance. The Grasps sub-section did not reach statistical significance at the 3-month follow-up session; however, the correlation between the TPOCS-A scores and the 3-month Grasps scores indicates a trend toward significance that may have been observed with a more robust sample size. In addition, when these values are plotted against the TPOCS-A total scores, a basic trend towards a positive relationship can readily be observed (see Appendix 10). Ultimately, the sample size of the current study limits the study's power; however, the calculated *r* value of 0.75 for the TPOCS-A – Grasps correlation indicates that a relationship does exist between these variables; thus, it is conceivable that with a larger sample size, this sub-section would significantly correlate with TPOCS-A scale total scores.

The strength of the C-T alliance may depend on a number of factors, including a child’s like or dislike for the therapist, the general mood or temperament of the child during the assessment session, or the child’s social skills. Of these factors, the current study assessed the child’s social skills indirectly through the use of the PEDI, wherein the caregiver rated the child’s social function by answering a series of questions. A statistically significant positive correlation was found between the total TPOCS-A scores and the two social function sub-sections of the PEDI at both assessment sessions where the PEDI was administered; statistically significant positive correlations were also found between the TPOCS-A quality of session scores and both social function sub-sections of the PEDI at the pre-assessment session. This suggests that the strength of the C-T alliance is positively related to a child’s social function, and implies that children with stronger social skills may develop a stronger C-T alliance, which may ultimately motivate them to ‘perform’ better during assessment sessions. As a result, the measurements taken during assessment sessions for children with better social skills may reflect their true ability more accurately. Children with weaker social skills, on the other hand, may not develop a strong C-T alliance, and consequently may not feel the need to perform to the best of their ability during an assessment session; as a result, an accurate reflection of their motor skills may not be measured.

The results of the current study support this conclusion, as children with higher social function scores as measured by the PEDI also scored higher on the QUEST at the pre-assessment and at the 3-month follow-up. Previous studies have demonstrated a consistent relationship between poorer social skills and social anxiety in children (Halford & Foddy, 1982; Morison & Masten, 1991; Chansky & Kendall, 1997; Coplan, Prakash, O'Neil, & Armer, 2004; Halford & Foddy, 2011); as such, children with poor social skills may find it more difficult to interact with, and perform motor tasks for, a stranger such as the acting therapist; in this study, the therapist was chosen specifically to be someone that none of the children had regular contact with in order to increase objectivity and avoid influential bias. If a therapist who has regular contact with the participants outside of the study were to conduct the motor assessments for a study, this may be criticized for its lack of impartiality; however, the results of the current study suggest that it may actually assist those children with lower social functioning to perform to the best of their abilities. Future studies should take this information into account when planning motor interventions for children with CP.

The TPOCS-A quality of session score was also significantly correlated with the social function sub-section of the functional skills domain of the PEDI at the pre-assessment; however, it was not significantly correlated with the social function sub-section of the caregiver assistance domain of the PEDI at the pre-assessment, and was not significantly correlated with either of the social function domains at the 3-month follow-up assessment. This may have occurred for a number of reasons; for this particular comparison, the video coders evaluated the quality of session, while the caregivers evaluated the children's social function. Since both are subjective third party assessments, this introduces room for error. Additionally, the social function assessments are meant to encompass an overall evaluation of the child's social skills, and are not designed to capture specific moods or temperaments of a particular day. As such, it is quite plausible that a video coder assessed a particular session's quality as poor while a parent evaluated his/her child as having good social skills overall.

Finally, it was found that the average grip strength scores for the affected limb in participants were positively and significantly correlated with the total TPOCS-A scores at all three assessment sessions when participant 2's scores were excluded. Moreover, there were statistically significant correlations between the TPOCS-A quality of session scores and the grip strength scores in the affected limb at the post-assessment and at the 3-month follow-up assessment when participant 2's scores were excluded. Several studies have reported that changes in grip strength are not observed following CIMT interventions in this population (Charles et al., 2001; Bonnier et al., 2006; Charles et al., 2006). It has been previously suggested that grip strength is difficult to measure in this population, due to potential limb deformity or extreme muscle weakness (Taub et al., 2007); however, the results of the current study suggest that the C-T interaction may play an important role in measurement of grip strength in this population. Correlations were found only for the affected limb; there were no significant correlations found between TPOCS-A scores and the unaffected limb at any of the assessment sessions. A possible explanation for this is that demonstrating grip strength in the unaffected limb may be fun for the participants, whereas demonstrating grip strength in the affected limb may be seen as difficult work. As such, having a strong C-T alliance may be more important when attempting this task for the affected limb, due to its more challenging nature. Support for this explanation came from several of the participants during this portion of the assessment, who commented that their affected limb was 'broken' or 'didn't work', or complained that it was too hard to squeeze the apparatus with that hand, and attempted to use their unaffected limb for assistance.

The small sample size in this study is certainly a limitation; with a larger sample size, it is possible that all grip strength scores would have correlated with all TPOCS-A scores on all assessment occasions. An alternative possibility is that grip strength is unrelated to C-T alliance; grip strength was a unique task, in that it appeared to be the most enjoyable task to the children. In addition, this task did not actually require any interaction with the therapist. Finally, this was the only task in which children received visual feedback for their performance; in all other motor assessments, the therapist would always say ‘thank you’ or ‘very good’ regardless of the level of performance of the child. During the grip strength assessments, however, the children squeezed the sphygmomanometer, and the movement of the pin showing them their strength may have acted as a motivating or discouraging factor, potentially influencing their effort in subsequent trials and sessions. The primary weakness of a correlation is that it does not imply causation; it is for this reason that extraneous factors such as the child’s motivation must be considered in a study of this nature

In addition to the potential of motivational factors affecting a child’s effort during the assessment sessions, fidelity to assessment protocol must also be considered. When motor assessments such as the QUEST are used, it is imperative that the tests be administered in a consistent and standardized fashion across all studies; this ensures that the fidelity of the assessments and the subsequent interpretation of the scores are maintained. The QUEST (DeMatteo et al., 1993) does not provide specific instructions regarding verbal prompting and redirection; this leaves room for error in the context of examining the C-T alliance, as each therapist will likely have his or her own techniques with regards to verbally assisting or redirecting clients during an assessment session. If multiple verbal prompts are given to one child during a motor assessment, while very few are given to another, the child receiving more verbal prompts may have a greater opportunity to perform the task correctly. This difference, if not considered, could reasonably contribute to the inconsistencies observed in the therapeutic outcomes for CIMT. If, however, a therapist were to adhere strictly to a script without any additional interaction with participants, this would render the analysis of the C-T interaction difficult to accomplish. As such, it is essential that a balance be achieved in this respect, whereby the development of a strong C-T alliance is promoted without compromising the fidelity to assessment protocol. For example, verbal prompting and redirecting should be consistent across studies; however, when the therapist is either recording or in between items on the assessment, engaging participants verbally should be encouraged. Additionally, a pre-session time set aside specifically to develop a strong C-T alliance could be implemented; the therapist could engage the child in activities and games that are unrelated to the motor assessments in order to enhance the C-T alliance prior to commencing the assessment session. Those administering standardized assessments should seek out ways to develop a strong alliance with clients while remaining consistent in their administration of the standardized assessments. In addition to the administration of the assessments, each child’s personal factors also influence the assessment session; personal factors are an important component of the WHO-ICF, as they ultimately influence a child’s activity and participation as per the WHO-ICF model (WHO, 2001).

C-T Interaction and the WHO-ICF

The overarching goal of implementing a CIMT intervention is to improve each child’s capacity to perform daily activities, such as self-care tasks and independent mobility, which would ultimately improve the child’s participation in those activities. When implementing a motor intervention in children, the personal factors outlined by the WHO-ICF must be considered (WHO, 2001). These include all factors that are unique to each child, and personality as well as social factors should be considered. These factors were particularly relevant to the current study, as each child’s distinctive qualities contributed to the development of a different C-T interaction during assessment sessions. One study examined participant opinions regarding a CIMT intervention that took place in a camp setting (Gilmore, Ziviani, Sakzewski, Shields, & Boyd, 2010); the participants commonly reported that they were encouraged to be in a place where they had the opportunity to interact with other children who were similar to them. Children reported feeling less alone and less different in this setting; as a result, conducting a therapeutic intervention such as CIMT in a day camp setting may motivate children and ultimately improve their participation, which in turn allows them to practice skills, which can ultimately improve the activities that they are able to do. Gilmore et al. (2010) also found that children expressed frustration and discomfort about wearing the glove (constraint), and further identified the considerable level of effort required to persist with the CIMT intervention. This is a relevant finding, as frustration and large amounts of required effort may negatively affect the level of motivation of the children, leading them to perform at a sub-optimal level (Charles et al., 2006; Gilmore et al., 2010). Despite the fact that children in the current study were not required to wear the splint during the assessment sessions, they were required to use a substantial amount of effort with their impaired arm in order to demonstrate the range of their motor abilities. The study by Gilmore et al. (2010) suggests that differing levels of motivation between children may help explain, at least in part, the reasons why the C-T alliances may differ between participants.

Personal factors such as the differing motivation levels of children are important to consider, as the diversity that exists between children will ultimately lead to diverse interactions with the assessing therapist. Specifically, the C-T interaction is itself a personal factor to be considered; each child will have a different temperament, personality, and social life, all of which will affect the interaction that occurs between the child and therapist. A child who has a quiet or shy disposition would be expected to behave differently from one with a livelier and more outgoing nature. For example, a shy child may only answer questions when asked; however, an outgoing child may offer opinions and information to the therapist more readily, without being prompted to do so. Similarly, a child who participates in community recreational activities may interact with the therapist in a different way than a child who does not participate in such activities. Community sports and other recreational activities afford children opportunities to develop their social skills, which may contribute to the social behaviour that they demonstrate during the assessment sessions. In addition, these recreational activities would likely present children with more opportunities to interact with unfamiliar adults in the form of instructors or coaches; as such, these children may be more at ease when interacting with the therapist during the assessment sessions. Each child will equally have different family structures, and each family will likely provide different levels of motivation and exhibit different beliefs, all of which affect the child’s current situation with respect to his or her health condition and current state of functioning. All of these factors, which will differ between children, will ultimately contribute to the type of interaction that occurs between the child and the therapist; this underlines the importance of considering the personal factors of each child when conducting motor interventions in children with spastic hemiplegic CP.

Suggestions for Future Directions

This study provides preliminary evidence that the strength of the C-T alliance is an important contributor to a child’s performance during an assessment session; as such, it is a factor that should be considered when planning a CIMT intervention in this population. Further investigation into the C-T alliance in the context of CIMT for children with hemiplegic CP is needed; future studies should use larger sample sizes in addition to a control group. Research that does not consider the C-T interaction may lead to inaccurate measurements during assessment sessions; ultimately, participant performance during the assessment sessions may not accurately reflect true motor ability. Future studies could incorporate a pre-test interview between participants and several different therapists that is videotaped and scored using the TPOCS-A to determine which therapist develops the strongest C-T alliance with each child. A positive C-T alliance might assist in maximizing the child’s involvement in activities that require his or her participation during assessment sessions, which would ultimately improve the accuracy of the measurements taken during those assessment sessions. In order to accurately and conclusively demonstrate the effectiveness of CIMT in children with spastic hemiplegic CP, the C-T interaction during the assessment session should be maximized to ensure that children are performing in a way that accurately reflects their motor abilities at all assessment times.

Conclusion

This study provides preliminary evidence of the importance of the C-T interaction during the assessment session as a factor influencing the measured outcomes following a modified CIMT intervention. The strength of the C-T alliance, the overall quality of the session, and the social function of the children involved were all demonstrated to have an effect on the child’s scores on standardized motor assessments during the assessment sessions. Future studies should consider the importance of the C-T alliance when implementing interventions in the population of children with CP, as this interaction has been demonstrated to be an important contributor to children’s scores on standardized motor assessments. As such, the strength of the C-T alliance may be a contributing factor to the inconsistent results that have been found in previous studies using CIMT in the pediatric population with CP. Future studies should also examine the C-T alliance when employing a motor intervention in this population in order to replicate the findings of the current study.

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THESIS SUMMARY

Cerebral palsy (CP) is the most common pediatric physical disability, and spastic hemiplegic CP is the most common type of CP. Children with spastic hemiplegic CP experience asymmetric motor impairment, with one side of the body being more affected than the other; the arm is typically more affected than the leg in this population. The impairments experienced by children with hemiplegic CP affect many aspects of their daily lives; these functional limitations ultimately interfere with proper motor development in multiple ways. Independence while performing self-care tasks, ability to fully participate in play and other group settings, and overall daily function are some of the areas in which children with hemiplegic CP experience difficulties. Effective motor interventions for children affected by hemiplegic CP are needed; research is needed that further investigates ways to promote functional improvements in this population. Constraint-induced movement therapy (CIMT) is a form of rehabilitative therapy that has been demonstrated to yield functional improvements for children with spastic hemiplegic CP; however, many studies have reported inconsistent findings with regards to the extent of the observed benefits following the intervention.

The current study's primary objective was to examine the effects of modified CIMT in the context of a day camp in six children aged 5-9 years with a diagnosis of spastic hemiplegic CP. The secondary objective was to investigate the child-therapist (C-T) interaction as a possible personal factor contributing to the inconsistencies that have been observed in the benefits reported by previous studies. We sought to examine the potential contribution of the C-T interaction during the actual assessment sessions as a factor influencing the child's scores on tests of motor performance. The World Health

Organization's International Classification of Functioning, Health and Disability (WHO-ICF) was the theoretical framework in which all results were analyzed and interpreted following the intervention.

The results from this study demonstrated that CIMT was able to produce improvements in the quality of use of the upper extremity as well as increased social function following the intervention. The improvements that were observed were maintained at the 3-month follow-up session; in addition, individual analysis of each participant's results yielded additional information on clinically significant improvements (measured by percent changes) that occurred following the CIMT intervention. Following CIMT, participants' abilities to perform certain motor tasks were improved; it is hoped that these improvements will increase each child's participation in these motor tasks in daily life.

The results of this study further provided preliminary evidence suggesting that the strength of the C-T interaction contributes to the perceived outcomes of the therapy, as the C-T alliance was found to be significantly and positively correlated with the scores participants obtained on motor assessments. Participants who developed stronger C-T alliances during the assessment sessions consistently scored higher on tests of motor performance. In accordance with the WHO-ICF, the results suggest that the C-T interaction may be a personal factor that should be considered when implementing modified CIMT in this population, as each child's experience with the assessing therapist is unique. These initial results suggest that the C-T interaction contributes to a participant's performance during the assessment session, and may ultimately affect his or her scores on tests of motor performance; this would have consequences for the perceived outcomes of CIMT. Previous research has not formally measured this interaction, which may explain some of the inconsistencies observed in the rehabilitation literature when employing CIMT in the pediatric population with spastic hemiplegic CP. Future studies should further investigate the potential influence of the C-T interaction on the perceived outcomes of CIMT interventions in children with hemiplegic CP. Future studies examining the C-T interaction should ideally do so using randomized controlled trials, robust sample sizes, and narrow age ranges; they should additionally consider personal factors such as impairment level of the affected limb and any secondary impairments that may influence the outcomes of the therapy. Should further studies support the preliminary findings of the current study, steps should be taken in order to establish the most appropriate methods for maximizing the C-T interaction when employing motor interventions such as CIMT in this population. The need to examine such personal factors as the C-T interaction in future studies outlines the importance of considering the WHO-ICF when implementing motor interventions such as modified CIMT; personal factors may vary greatly between individuals and, as the C-T interaction demonstrated in the current study, they can have important clinical implications. Finally, this study implemented modified CIMT in a natural setting, which is an important consideration that has been gaining attention in the recent literature; applying motor interventions in more natural settings is believed to facilitate the transfer of any acquired skills into daily activities.

In summary, the results of this study indicate that modified CIMT, administered in a day camp setting, is effective in inducing lasting and meaningful functional changes in children aged 5-9 years with spastic hemiplegic CP. This study also contributed something unique to the literature in its investigation of the C-T interaction as a possible factor influencing the perceived outcome of the intervention. Finally, the issue of clinical versus statistical significance was addressed; detailed analysis of the results obtained in the current study revealed that many clinically significant improvements were demonstrated following CIMT. Movement interventions such as modified CIMT aim primarily to promote improved functional outcomes for those involved; this study successfully supported this objective, and saw clinically significant improvements in six children with spastic hemiplegic CP.

Future studies should work towards consistent incorporation of the conceptual framework of the WHO-ICF into their methodology as well as into their discussion of any results obtained. The WHO-ICF is essential to use as a framework when mtor interventions for children with disabilities are planned and implemented; this model considers the child as a whole, by taking into account individual, family, and environmental factors when describing an individual’s health condition and overall functional status. It was through the lens of the WHO-ICF that we were able to consider each child as an individual with unique characteristics, personality traits, family structure, and social environment; this ultimately allowed us to identify the C-T interaction as a possible influence on the perceived outcomes of the intervention. The C-T interaction revealed its importance through the results of this study, and it challenges the null results obtained in previous studies using CIMT in children with CP. If previous studies have not considered or controlled for personal factors in their methodologies, then the effectiveness of CIMT may not be able to be conclusively established. Each individual’s personal characteristics and environmental context are essential to consider when motor interventions are being discussed for children with spastic hemiplegic CP; without accounting for individual differences, researchers are essentially searching for a ‘one size fits all’ therapy. Since the population of children with spastic hemiplegic CP is so heterogeneous in their impairments and areas of difficulty and ability, it is unreasonable to assume that one therapeutic ‘recipe’ will suffice for all members of this population. Personal factors such as the C-T interaction, in accordance with the WHO-ICF, must be scrutinized in future research in order to conclusively determine who will benefit most from CIMT in the population of children with a diagnosis of spastic hemiplegic CP.

SECTION 5: APPENDICES

APPENDICES

Appendix 1: Certificate of Approval from the University of Ontario Institute of Technology Research Ethics Board

RESEARCH ETHICS BOARD
OFFICE OF RESEARCH SERVICES

Date: April 18th, 2012
To: Ashley Thompson (PI), Serena Chow (Co-PI), Cathy Vey (Co-PI), Meghann Lloyd (Supervisor)
From: Amy Leach, REB Chair
REB File #: 11-093
Project Title: Effects of Constraint-Induced Movement Therapy in Children Aged 5-8 with Spastic Hemiplegic Cerebral Palsy: A Day Camp Model
DECISION: APPROVED
START DATE: April 18th, 2012 EXPIRY: April 18th , 2013

The University Of Ontario Institute Of Technology Research Ethics Board has reviewed and approved the above research proposal. The application in support of the above research project has been reviewed by the Research Ethics Board to ensure compliance with the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS2) and the UOIT Research Ethics Policy and Procedures.

Please note that the Research Ethics Board (REB) requires that you adhere to the protocol as last reviewed and approved by the REB.

Always quote your REB file number on all future correspondence.
Please familiarize yourself with the following forms as they may become of use to you.

- **Change Request Form:** any changes or modifications (i.e. adding a Co-PI or a change in methodology) must be approved by the REB through the completion of a change request form before implemented.
- **Adverse or unexpected Events Form:** events must be reported to the REB within 72 hours after the event occurred with an indication of how these events affect (in the view of the Principal Investigator) the safety of the participants and the continuation of the protocol. (I.e. un-anticipated or un-mitigated physical, social or psychological harm to a participant).
- **Research Project Completion Form:** must be completed when the research study has completed.

- **Renewal Request Form:** any project that exceeds the original approval period must receive approval by the REB through the completion of a Renewal Request Form before the expiry date

REB Chair
Dr. Amy Leach, SSH
amy.leach@uoit.ca

Ethics and Compliance Officer
Sascha Tuuha, (905) 721-8668 ext. 3693
compliance@uoit.ca

has passed.

All Forms can be found at http://research.uoit.ca/EN/main/231307/Research_Forms.html.

Appendix 2: Certificate of Ethical Approval from the Grandview Children's Centre Ethics Committee

GRANDVIEW
CHILDREN'S
CENTRE

March 2, 2012

UOIT Research Ethics Board
2000 Simcoe Street North
Oshawa, Ontario
L1H 7K4

Dear UOIT Research Ethics Board:

I am pleased to provide a letter confirming our participation in the Master's Thesis of Ms. Ashley Thompson, under the supervision of Dr. Meghann Lloyd, on Constraint Induced Therapy (also known as "Cast Camp"), for 5-8 year old children with hemiplegic cerebral palsy.

We are pleased to be hosting and collaborating with these researchers.

Sincerely,

Lorraine Sunstrum-Mann, ECEDH, RN, BA, MBA
Executive Director

... leading the way to excellence in services for children and youth with special needs and their families in Durham Region.
600 Townline Road South, Oshawa, ON L1H 7K6 • 905.728.1673 • 1.800.304.6180 • Fax 905.728.2961
www.grandviewcc.ca
A Registered Charitable Organization

Appendix 3: Parent/Guardian Consent Form for Cast Camp

UOIT
CHALLENGE INNOVATE CONNECT

UNIVERSITY OF ONTARIO
INSTITUTE OF TECHNOLOGY

2000 SIMCOE STREET NORTH
OSHAWA, ON, CANADA L1H 7K4

PH905.721.8668
www.uoit.ca

Effects of Constraint-Induced Movement Therapy in Children Aged 5-9 with Spastic Hemiplegic Cerebral Palsy: A Day Camp Model

Informed Consent to Participate

Investigators:

Ashley Thompson	Master's Candidate in Health Sciences University of Ontario Institute of Technology ashley.thompson@uoit.ca 905-721-8668, ext 2953
Serena Chow	Occupational Therapist Grandview Children's Centre (Oshawa) 905-728-1673, ext 2350 serena.chow@grtc.ca
Cathy Vey	Occupational Therapist Grandview Children's Centre (Oshawa) 905-728-1673, ext 2235 cathy.vey@grtc.ca.
Dr. Meghann Lloyd	Faculty of Health Sciences University of Ontario Institute of Technology 905-721-8668, ext 5308 meghann.lloyd@uoit.ca

Purpose:

Cerebral Palsy (CP) is the most common pediatric physical disability, occurring in 1 in 500 children; spastic hemiplegic CP is the most common type of CP. Children with spastic hemiplegic CP experience upper-limb (arm) impairment on one side of their body; this arm is generally referred to as the 'affected limb'. We need to find ways to help treat the affected limb; constraint-Induced Movement Therapy (CIMT) is a newer therapy for CP that involves constraining the less affected upper-limb using a splint or a cast, and having the children practice using their more affected limb during this time.

The purpose of this study is to see if there are any benefits to your child after participating in constraint-induced movement therapy (CIMT). Past studies have shown that CIMT can improve the function of the more affected limb; CIMT can also increase the child's spontaneous use of the affected limb in day-to-day tasks and self-care activities (e.g. dressing, feeding, and toileting). In many studies, these improvements last for months; more research is needed in this area to support the effectiveness of CIMT in children with spastic hemiplegic cerebral palsy. The results from this study will contribute to the scientific literature on CIMT in the pediatric population affected by spastic hemiplegic CP.

If you choose to enroll your child as a participant in this study, he or she will attend a two-week day camp at Grandview Children's Centre from July 3-6, 2012 and July 9-13, 2012; your child will be asked to wear a splint on the less affected arm for the duration of the camp. We are interested in seeing how having the splint on the less affected arm will affect the child's use of the more affected arm right after camp and 3 months later. Please note that this study is taking place in a camp setting, and all children who are enrolled in 'camp' for these two weeks will actually be participants in the study; if you wish to enroll your child in camp but are not interested in participating in the study, there are other weeks of camp throughout the summer that you may choose.

Recruitment

Participants will include a maximum of 17 children with a diagnosis of spastic hemiplegic CP between 5 and 9 years of age; the maximum number of participants was determined by camp space and staffing constraints. In order to be included in the camp, participants must meet the following criteria: (1) Must be able to walk independently; (2) must be able to participate in a camp setting; (3) must be willing to travel to Grandview Children's Centre for the duration of the camp and for the three assessment sessions. Participants will not be eligible to participate in the study if they meet the following criteria: (1) Have had orthopedic (correctional) surgery on the affected upper limb; (2) have had dorsal rhizotomy procedure (surgery to cut the nerve roots that cause spasticity). Regardless of any secondary conditions or any other impairment or symptoms that may be present, all children who satisfy the above criteria will be included in the study.

Study Procedures:

This study will take place in a 'camp' setting; to participate in this study we will ask your child to attend a two- week day camp that will take place from July 3 – 6, 2012 and July 9 – 13, 2012 from 9am – 4pm at Grandview Children's Centre (participation in the study will not cost you anything). We will also ask you and your child to visit Grandview Children's Centre for about one hour on three separate occasions (and complimentary parking will be provided). The first assessment session will take place 2-3 weeks prior to the camp's beginning; the second assessment session will take place 2-3 weeks after the camp's end; the third assessment session will take place 3 months following the camp. All of the assessment sessions will take place at the convenience of the families who choose to participate; we will work with you to set up a time that is convenient for you. All assessments will be performed by an Occupational Therapist at Grandview Children's Centre.

This study includes evaluation of certain motor activities, and an evaluation of how children perform daily activities by themselves. We will ask you to complete a questionnaire on behalf of your child that includes general background information, as well as a questionnaire that will help us to better understand how your child uses his or her hand at home every day. We will measure certain aspects of your child's motor performance using a selection of different tests.

Details about each part of the study are included below:

The following is a list of the assessments which will be used in this study; if you have any questions regarding any of these assessments, one of the researchers would be happy to explain the details to you:

- Range of motion
- Grip strength
- Modified Ashworth Scale (tests for level of spasticity)
- Quality of Upper Extremity Skills Test (standardized motor assessment)
- The Pediatric Evaluation of Disability Inventory (questionnaire)
- Grandview questionnaire for parents/guardians (questionnaire)

In addition to these assessments, there is a Grandview questionnaire for camp counsellors that each camp counsellor will fill out on the first and last day of camp. This questionnaire contains the same questions as the Grandview questionnaire for parents; however, this questionnaire only assesses the child's performance on certain skills (it is only a portion of the parent/guardian questionnaire). This questionnaire will give us additional insight on each child's performance.

<u>On your first visit Grandview</u>, children will be fitted for a splint; as a benefit of participating in this study, each child will receive a splint at the end of the study (after the 3-month follow-up assessment)

The following table illustrates which assessments will occur during each assessment session, along with the approximate dates for the study:

	Occupational Therapist Assessments: (children)	Questionnaires (parents)	
	• Range of Motion • Grip Strength • Modified Ashworth Scale • QUEST (Motor Assessment)	Pediatric Evaluation Disability Inventory	Grandview Questionnaire
Assessment 1: Pre-test session (June 11-29, 2012)	Yes	Yes	Yes
Camp (July 3-6, 2012 and July 9-13,2012)			
Assessment 2: Post-test session (July 16-August 3, 2012)	Yes	No	Yes
Assessment 3: 3-month follow-up session (October 16-November 3, 2012)	Yes	Yes	Yes

Cast Camp will take place from July 3 – July 6, 2012 and July 9 – July 13, 2012 from 9am – 4pm at Grandview Children's Centre. Upon arrival to Grandview, all children will have their Benik© splint put on their less affected upper limb. During the day, children will perform age appropriate activities which will be led by camp counselors hired by Grandview Children's Centre. Examples of the activities performed at camp include physical/outdoor games and activities, arts and crafts, and group activities (singing, team games). At the end of each camp day, before going home, all children will have their Benik© splint removed.

Children will not be taking the splint home at the end of camp, and we ask that children not wear a restraint of any kind on their less affected limb in the time period between the end of camp and the 3-month follow-up assessment.

Following the 3-month follow-up assessment, an optional one-hour parent training session will take place. At this session, all children will receive a Benik© splint. During this session, an Occupational Therapist from Grandview Children's Centre will provide information regarding proper and safe use of the splint. The session will also provide information regarding how to manage any redness and irritation that may occur with the use of the splint, and will offer tips and strategies for parents in order to promote and/or maintain functional improvement of the affected limb.

Videotaping of Assessments

Finally, we are interested in looking at the relationship between the child and the therapist during the assessment sessions. In order to better understand this relationship, we will need to videotape the sessions (with your consent) to make sure that we can assess each child's performance in the same way. The videotapes will only be viewed by those individuals directly involved in the research (Ashley Thompson, Serena Chow, Cathy Vey and Dr. Meghann Lloyd).

Consent to be videotaped is completely voluntary, and choosing not to consent to this portion of the study will have no effect on your child's participation in the study. If you consent to have your child's assessment sessions videotaped, you child **may** be selected to have his or her assessment sessions videotaped. Although the child will be seen on the videotape, no additional information will be added to identify any of the participants (name, age, etc.).

Benefits:

All activities performed during camp will be age appropriate, and there will be a potential opportunity to learn new skills as a result of attending camp. In addition, there will be a 2:1 child to staff ratio for Cast Camp, which will make sure that each child receives a personalized experience with the staff during camp. Children may also experience gains in the functional use of the more affected limb following camp.

While there may be no direct benefit to your child for participating in this study, the research findings may help children who have hemiplegic CP in the future; it may help other children with upper-limb impairment to improve their use of their more affected arm. You can withdraw your child from the study at any time, and you are not required to provide a reason for doing so. You may also request a report detailing your child's personal results.

All children will also receive a Benik© splint for at-home use as an added benefit and as a thank you for their participation in the study.

Risks:

Your child's participation in this study does not pose any risk that differs from what children would normally encounter in daily life. All camp activities are similar to occupational therapy sessions and any regular day camp. As with any physical activity, there is a risk of injury; however, safety is our first priority. All camp staff members are trained in First Aid and CPR, and in the event of an injury, the facility's standard emergency procedures will be followed. In the event that your child suffers an injury as a direct result of participating in this study, normal legal rules for compensation will apply. By signing this consent form you are in no way waiving your legal rights or releasing the investigator and the sponsor from their legal and professional responsibilities.

Possible risks associated with wearing the Benik© splint include minor skin irritation or redness due to the splint rubbing the skin. The arm will be checked daily by the occupational therapist who is applying the splint, and if necessary, ointment and/or additional padding will be used to increase the comfort of the child while wearing the splint.

Data Storage and Confidentiality:

The data collected in this study used for current and potentially future research will be secured safely. All information that you and your child provide will be numbered and will not contain names. Overall results may be published for scientific purposes, and may also be used in the future for scientific and research purposes, but participant identity will remain confidential. Limits of this confidentiality include situations of suspected child abuse, concerns of harm to self or others, or any request for information by court order.

Right to Withdraw:

You are free to withdraw your child at any time without penalty; your child may continue to attend ‘camp’ with the other children in the study without cost. If you choose to withdraw, any data or videotapes that have been collected from your child will be destroyed and will not be used in any analyses, publications or future research.

Dissemination:

At your request, you can receive a copy of the results from this study following its completion. You can request a summary of your child’s personal results once he/she has completed his/her final assessment session.

Questions about the study:

If you have questions about this study, please contact Ashley Thompson at 905-721-8668, ext. 2953 or Dr. Meghann Lloyd at 905-721-8668 ext.5308. This study has been reviewed and approved by the University of Ontario Institute of Technology Research Ethics Board, which is a committee of the university whose goal is to ensure the protection of the rights and welfare of people participating in research. The Board’s work is not intended to replace a parent/guardian or child’s judgment about what decisions and choices are best for you. If you have any questions about your child’s rights as a research participant you may contact the University of Ontario Institute of Technology Research Ethics Board at 2000 Simcoe St. N., Oshawa, ON, L1H 7l7, 905-721-8668 ext 3693 or compliance@uoit.ca

Effects of Constraint-Induced Movement Therapy in Children Aged 5-9 with Spastic Hemiplegic Cerebral Palsy: A Day Camp Model

I, ...,
(Your Name)

the parent/guardian of .... :
(Your Child's Name)

☐ **Give consent** to my child's participation in the above study.

☐ **Give consent** to my child being videotaped as part of their participation.

☐ **Give consent** to my child's data potentially being used in future research to help with therapies for children with hemiplegic CP

I have read and understood the attached information sheet or had the attached information sheet verbally explained to me, and have received a copy of this consent form. I have been fully informed of the details of the study and have had the opportunity to discuss my concerns. I understand that I am free to withdraw my child at any time or not answer questions.

____

Name of child

____________________________________ ____________________

Name of Parent/Guardian Contact phone number

____________________________________ ____________________

Signature of Parent/Guardian Date

____________________________________ ____________________

Investigator's signature Date

Appendix 4: Child Assent Form for Cast Camp

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UNIVERSITY OF ONTARIO
INSTITUTE OF TECHNOLOGY
2000 SIMCOE STREET NORTH
OSHAWA, ON, CANADA L1H 7K4
PH 905.721.8668
www.uoit.ca

Effects of Constraint-Induced Movement Therapy in Children Aged 5-9 with Spastic Hemiplegic Cerebral Palsy: A Day Camp Model

Child Assent Form

Hi [child's name], you're here today because your [Mom or Dad or Guardian] has said that it's okay for you to be a part of my research project; but first I want to ask you if it's okay with you. The reason we are doing this project is to help us understand more about what kinds of things might help you to use your helper hand better when you're at home or at school.

We will ask you to play some games with us when you come here to Grandview to visit us, and you will also get to go to camp with some other kids this summer. We will also have you show us how you can use your helper hand for different things. This means we will play some games together like 'Simon Says', and we will ask you to use toys like blocks and make shapes with them.

We will ask you to wear a splint (like a cast that we can put on and take off of you) on your better arm when you come to camp, just while you're here during the day. This will help us see if your helper hand gets better at moving around after camp is over.

For those whose parents/guardians have consented to have their child videotaped: We are going to videotape you when you show us your different skills.

You don’t have to participate if you don’t want to, and the information we get won’t be shared with anyone except you and your parents. You can decide to stop the study at any time.

Do you want to participate in this project? __________ yes ________ no
Is it okay if we videotape you? __________ yes ___________ no

Appendix 5: Recruitment Poster for Cast Camp 2012

Do you have a child **between the ages of 5-8 years**
with a diagnosis of **spastic hemiplegic cerebral palsy?**

Volunteers are needed to participate in a **two-week day camp this summer**!

This study is investigating the effects of casting the affected limb in children with hemiplegic CP during camp hours on their ability to use the affected limb following camp.

There will be **no cost** for participation in this study!

For more information, please
contact Ashley or
Meghann:

905.721.8668 ext. 2953

ashley.thompson@uoit.ca
meghann.lloyd@uoit.ca

Appendix 6: Children's Treatment Centre Questionnaire for Parents/Guardians

CTC Questionnaire for Parents

Client Name: ______________________________________ DOB: ______________________

Primary OT: _______________________________ Affected Upper Extremity: _____L ____R

Pre-Assessment

Areas of function:	**Performance:** Rate the way your child performs these functions.	**Importance:** Rate how important it is that your child improves in these functions.	**Satisfaction:** Rate your satisfaction with the way your child performs these functions.
	1 2 3 4 5 6 7 8 9 10 Not Able to do it able to do Extremely well it at all	1 2 3 4 5 6 7 8 9 10 Not Extremely Important Important at all	1 2 3 4 5 6 7 8 9 10 Not Extremely satisfied Satisfied at all
1. Frequency of Use My child is observed using their affected hand to participate in activities.			
2. Spontaneity of Use My child uses their affected hand in activity without being reminded to do so.			
3. Quality of Grasp a). Gross Grasp: My child holds onto, uses and releases large objects within their affected hand.			
b). Precision Grasp: My child holds onto, uses and releases small objects within their affected finger tips.			
3. Self-Care Skills a). Feeding: My child feeds him/herself independently with utensils and a cup.			
b). Toileting: My child toilets him/herself independently, including managing clothing.			
c). Dressing: My child dresses him/herself independently including fasteners and zippers.			

Therapist's Signature: ____

***** THANK YOU TO ERINOAK KIDS CENTRE FOR TREATMENT AND DEVELOPMENT FOR THE FORMAT OF THIS QUESTIONNAIRE*****

Appendix 7: Performance Section of Children's Treatment Centre Questionnaire for Camp Counselors

CTC Questionnaire for Camp Counselors

Client Name: ______________________________________ DOB: ____________________________

Camp Counsellor Name: _______________________________________

Affected Upper Extremity: _____L ____R

Pre-Assessment

Areas of function:	**Performance:** Rate the way the child performs these functions.
	1 2 3 4 5 6 7 8 9 10 Not able to do it at all … Able to do it Extremely well
1. Frequency of Use The child is observed using their affected hand to participate in activities.	
2. Spontaneity of Use The child uses their affected hand in activity without being reminded to do so.	
3. Quality of Grasp a). Gross Grasp: The child holds onto, uses and releases large objects within their affected hand.	
b). Precision Grasp: The child holds onto, uses and releases small objects within their affected finger tips.	
3. Self-Care Skills a). Feeding: The child feeds him/herself independently with utensils and a cup.	
b). Toileting: The child toilets him/herself independently, including managing clothing.	
c). Dressing: The child dresses him/herself independently including fasteners and zippers.	

Therapist's Signature: _______________________________________

***** THANK YOU TO ERINOAK KIDS CENTRE FOR TREATMENT AND DEVELOPMENT FOR THE FORMAT OF THIS QUESTIONNAIRE*****

Appendix 8: Raw Data in Tables

Pediatric Evaluation of Disability Inventory – Functional Skills and Caregiver Assistance Scales
Pre-Assessment (Raw Data)

	Functional Skills								
Participant	Self-Care Raw	Self-Care Scaled	Standard Error	Mobility Raw	Mobility Scaled	Standard Error	Social Function Raw	Social Function Scaled	Standard Error
1	59	68.3	1.8	57	66.8	1.8	54	64.6	1.7
2	60	69.1	1.8	57	66.8	1.8	58	67.6	1.8
3	44	58.0	1.6	58	67.6	1.8	56	66.0	1.7
4	54	64.6	1.7	55	65.3	1.7	53	63.9	1.7
5	64	72.6	2.0	53	63.9	1.7	61	70.0	1.8
6	65	73.6	2	59	68.3	1.8	62	70.8	1.9
	Caregiver Assistance								
Participant	Self-Care Raw	Self-Care Scaled	Standard Error	Mobility Raw	Mobility Scaled	Standard Error	Social Function Raw	Social Function Scaled	Standard Error
1	35	74.5	4.7	35	74.5	4.7	22	57.9	3.5
2	36	76.7	5.2	35	74.5	4.7	25	61.1	3.5
3	20	55.7	3.5	34	72.7	4.4	18	53.4	3.6
4	32	69.6	4.0	34	72.7	4.4	23	59.0	3.5
5	38	83.2	7.2	32	69.6	4.0	24	60.1	3.5
6	40	100	0	34	72.7	4.4	24	60.1	3.5

Pediatric Evaluation of Disability Inventory – Modification Frequencies for Self-Care, Mobility, and Social Function
Pre-Assessment (Raw Data)

Category	**Participant**	**Modification Frequencies**			
		None	Child	Rehabilitation	Extensive
Self-Care	1	2	4	0	2
	2	3	5	0	0
	3	0	8	0	0
	4	0	5	2	1
	5	6	2	0	0
	6	4	4	0	0
Mobility	1	7	0	0	0
	2	6	1	0	0
	3	6	1	0	0
	4	0	6	1	0
	5	5	2	0	0
	6	6	1	0	0
Social Function	1	2	3	0	0
	2	4	1	0	0
	3	0	5	0	0
	4	0	3	2	0
	5	4	1	0	0
	6	3	2	0	0

Pediatric Evaluation of Disability Inventory – Functional Skills and Caregiver Assistance Scales
3-Month Assessment (Raw Data)

	Functional Skills								
Participant	Self-Care Raw	Self-Care Scaled	Standard Error	Mobility Raw	Mobility Scaled	Standard Error	Social Function Raw	Social Function Scaled	Standard Error
1	53	63.9	1.7	55	65.3	1.7	59	68.3	1.8
2	61	70.0	1.8	58	67.6	1.8	60	69.1	1.8
3	48	60.5	1.6	59	68.3	1.8	57	66.8	1.8
4	55	65.3	1.7	58	67.6	1.8	54	64.6	1.7
5	67	75.9	2.3	57	66.8	1.8	63	71.7	1.9
6	69	79.0	2.8	59	68.3	1.8	63	71.7	1.9
	Caregiver Assistance								
Participant	Self-Care Raw	Self-Care Scaled	Standard Error	Mobility Raw	Mobility Scaled	Standard Error	Social Function Raw	Social Function Scaled	Standard Error
1	36	76.7	5.2	34	72.7	4.4	24	60.1	3.5
2	40	100	0	35	74.5	4.7	25	61.1	3.5
3	27	63.4	3.5	34	72.7	4.4	14	48.6	3.8
4	39	89.7	10.3	33	71.1	4.1	23	59.0	3.5
5	38	83.2	7.2	34	72.7	4.4	24	60.1	3.5
6	28	64.5	3.6	23	59.0	3.5	26	62.2	3.5

Pediatric Evaluation of Disability Inventory – Modification Frequencies for Self-Care, Mobility, and Social Function
3-Month Assessment (Raw Data)

Category	**Participant**	**Modification Frequencies**			
		None	Child	Rehabilitation	Extensive
Self-Care	1	5	3	0	0
	2	8	0	0	0
	3	1	7	0	0
	4	8	0	0	0
	5	6	2	0	0
	6	8	0	0	0
Mobility	1	6	1	0	0
	2	7	0	0	0
	3	7	0	0	0
	4	7	0	0	0
	5	6	1	0	0
	6	7	0	0	0
Social Function	1	4	1	0	0
	2	5	0	0	0
	3	1	4	0	0
	4	5	0	0	0
	5	4	1	0	0
	6	5	0	0	0

Quality of Upper Extremity Skills Test (QUEST)
Pre-Assessment (Raw Data)

	QUEST Category				
Participant	**Dissociated Movements**	**Grasps**	**Weight Bearing**	**Protective Extension**	**Total QUEST Score**
1	70.31	69.57	92.00	60.00	72.97
2	75.00	69.57	100.00	83.33	81.98
3	70.31	60.87	98.00	50.00	69.80
4	54.84	56.52	74.00	0.00	61.79
5	93.75	82.61	100.00	91.67	92.01
6	92.19	82.61	100.00	91.67	91.62

Quality of Upper Extremity Skills Test (QUEST)
Post-Assessment (Raw Data)

	QUEST Category				
Participant	**Dissociated Movements**	**Grasps**	**Weight Bearing**	**Protective Extension**	**Total QUEST Score**
1	62.50	78.26	74.00	75.00	72.44
2	82.81	78.95	98.00	100.00	89.94
3	67.19	65.22	74.00	66.67	68.27
4	53.23	52.17	50.00	41.67	49.27
5	100.00	82.61	100.00	100.00	95.65
6	93.75	95.65	100.00	100.00	97.35

Quality of Upper Extremity Skills Test (QUEST)
3-Month Assessment (Raw Data)

	QUEST Category				
Participant	**Dissociated Movements**	**Grasps**	**Weight Bearing**	**Protective Extension**	**Total QUEST Score**
1	56.25	82.61	74.00	75.00	71.97
2	76.56	73.68	88.00	100.00	84.56
3	78.13	82.61	92.00	66.67	79.85
4	51.56	47.37	0.00	41.67	46.87
5	95.31	100.00	100.00	83.33	94.66
6	96.88	100.00	100.00	100.00	99.22

Range of Motion – Pre-Assessment (Raw Data)

Active Range									
Participant	**Shoulder Abduction (Range = 0 - 180°)**	**Shoulder Flexion (Range = 0 - 180°)**	**Shoulder Internal rotation (Range = 0 - 90°)**	**Shoulder External rotation (Range = 0 - 90°)**	**Elbow Flexion (Range = 0 - 150°)**	**Elbow Extension (0°)**	**Forearm supination (Range = 0 - 80° - 90°)**	**Forearm Pronation (Range = 0 - 80° - 90°)**	**Wrist Flexion (Range = 0 - 80°)**
1	100	180	90	90	150	0	90	90	66
2	180	180	90	52	150	0	90	90	80
3	180	180	90	42	72 at neutral; 150 when pronated	0	90	90	84
4	102	160	90	0	150	Could not measure	0	90	80
5	180	180	90	90	150	0	90	90	80
6	180	180	90	90	150	0	90	90	80
Active Range Continued									
Participant	**Wrist Extension (Range = 0 - 70°)**	**Ulnar Deviation (Range = 0 - 30°)**	**Radial Deviation (Range = 0 - 20°)**	**Finger Flexion**	**Finger Extension**	**Thumb Flexion**	**Thumb Extension**	**Thumb Abduction**	
1	0	44	0	full	Full	full	full	n/a	
2	42	8	0	full	Full	To pad of index	full	full	
3	34	21	0	not full (each digit recorded)	Full	full	45-90	To PIP of middle finger (D2)	
4	0	Could not measure	Could not measure	Could not measure	Not tested (hyperextends at MCPs)	Could not measure	Could not measure	Could not measure	
5	80	8	0	full	Full	full	full	full	
6	70	52	12	full	Full	full	full	full	

Range of Motion – Pre-Assessment (Raw Data)

Passive Range									
Participant	**Shoulder Abduction (Range = 0 - 180°)**	**Shoulder Flexion (Range = 0 - 180°)**	**Shoulder Internal rotation (Range = 0 - 90°)**	**Shoulder External rotation (Range = 0 - 90°)**	**Elbow Flexion (Range = 0 - 150°)**	**Elbow Extension (0°)**	**Forearm supination (Range = 0 - 80° - 90°)**	**Forearm Pronation (Range = 0 - 80° - 90°)**	**Wrist Flexion (Range = 0 - 80°)**
1	180	180	90	90	150	0	90	90	80
2	180	180	90	90	150	0	90	90	80
3	180	180	90	90	150	0	90	90	80
4	160	180	90	90	150	5	90	90	80
5	180	180	90	90	150	0	90	90	80
6	180	180	90	90	150	0	90	90	80

Passive Range Continued									
Participant	**Wrist Extension (Range = 0 - 70°)**	**Ulnar Deviation (Range = 0 - 30°)**	**Radial Deviation (Range = 0 - 20°)**	**Finger Flexion**	**Finger Extension**	**Thumb Flexion**	**Thumb Extension**	**Thumb Abduction**	
1	70	68	26	Full	full	Full	full	full	
2	70	82	64	Full	full	Full	full	full	
3	70	30	66 - pain	Full	full	Full	full	full	
4	48	60	42	Full	full	Full	full	full	
5	70	46	62	Full	full	Full	full	full	
6	70	64	52	Full	full	Full	full	full	

Range of Motion – Post-Assessment (Raw Data)

Active Range									
Participant	**Shoulder Abduction (Range = 0 - 180°)**	**Shoulder Flexion (Range = 0 - 180°)**	**Shoulder Internal rotation (Range = 0 - 90°)**	**Shoulder External rotation (Range = 0 - 90°)**	**Elbow Flexion (Range = 0 - 150°)**	**Elbow Extension (0°)**	**Forearm supination (Range = 0 - 80° - 90°)**	**Forearm Pronation (Range = 0 - 80° - 90°)**	**Wrist Flexion (Range = 0 - 80°)**
1	180	180	90	90	150	138	90	90	80
2	180	180	90	90	150	0	90	90	80
3	180	180	90	90	150	162	90	90	80
4	Not tested	130	Not tested	Not tested	150	140	0	90	80
5	180	180	90	90	150	0	90	90	80
6	180	180	90	90	150	0	90	90	80
Active Range Continued									
Participant	**Wrist Extension (Range = 0 - 70°)**	**Ulnar Deviation (Range = 0 - 30°)**	**Radial Deviation (Range = 0 - 20°)**	**Finger Flexion**	**Finger Extension**	**Thumb Flexion**	**Thumb Extension**	**Thumb Abduction**	
1	0	42	0	Full	full	full	full	Across to tip of index	
2	70	46	20	Full	full	To PIP of middle finger	full	full	
3	0	0	0	Full	full	To PIP of middle finger	0	full	
4	0	Not tested	Not tested	Not tested	Not tested	Not tested	Not tested	Not tested	
5	70	30	20	Full	full	full	full	full	
6	70	52	26	Full	full	full	full	full	

Range of Motion – Post-Assessment (Raw Data)

<table>
<tr><th colspan="10">Passive Range</th></tr>
<tr><th>Participant</th><th>Shoulder Abduction (Range = 0 - 180°)</th><th>Shoulder Flexion (Range = 0 - 180°)</th><th>Shoulder Internal rotation (Range = 0 - 90°)</th><th>Shoulder External rotation (Range = 0 - 90°)</th><th>Elbow Flexion (Range = 0 - 150°)</th><th>Elbow Extension (0°)</th><th>Forearm supination (Range = 0 - 80° - 90°)</th><th>Forearm Pronation (Range = 0 - 80° - 90°)</th><th>Wrist Flexion (Range = 0 - 80°)</th></tr>
<tr><td>1</td><td>180</td><td>180</td><td>90</td><td>90</td><td>150</td><td>0</td><td>90</td><td>90</td><td>80</td></tr>
<tr><td>2</td><td>180</td><td>180</td><td>90</td><td>90</td><td>150</td><td>0</td><td>90</td><td>90</td><td>80</td></tr>
<tr><td>3</td><td>180</td><td>180</td><td>90</td><td>90</td><td>150</td><td>0</td><td>90</td><td>90</td><td>80</td></tr>
<tr><td>4</td><td>180</td><td>180</td><td>90</td><td>90</td><td>150</td><td>10</td><td>90</td><td>90</td><td>80</td></tr>
<tr><td>5</td><td>180</td><td>180</td><td>90</td><td>90</td><td>150</td><td>0</td><td>90</td><td>90</td><td>80</td></tr>
<tr><td>6</td><td>180</td><td>180</td><td>90</td><td>90</td><td>150</td><td>0</td><td>90</td><td>90</td><td>80</td></tr>
<tr><th colspan="10">Passive Range Continued</th></tr>
<tr><th>Participant</th><th>Wrist Extension (Range = 0 - 70°)</th><th>Ulnar Deviation (Range = 0 - 30°)</th><th>Radial Deviation (Range = 0 - 20°)</th><th>Finger Flexion</th><th>Finger Extension</th><th>Thumb Flexion</th><th>Thumb Extension</th><th>Thumb Abduction</th><th></th></tr>
<tr><td>1</td><td>70</td><td>30</td><td>10</td><td>Full</td><td>full</td><td>full</td><td>full</td><td>full</td><td></td></tr>
<tr><td>2</td><td>70</td><td>76</td><td>20</td><td>Full</td><td>full</td><td>full</td><td>full</td><td>full</td><td></td></tr>
<tr><td>3</td><td>70</td><td>30</td><td>20</td><td>Full</td><td>full</td><td>full</td><td>full</td><td>full</td><td></td></tr>
<tr><td>4</td><td>28</td><td>Not Tested</td><td>Not Tested</td><td>Full</td><td>full</td><td>full</td><td>full</td><td>full</td><td></td></tr>
<tr><td>5</td><td>70</td><td>30</td><td>20</td><td>Full</td><td>full</td><td>full</td><td>full</td><td>full</td><td></td></tr>
<tr><td>6</td><td>70</td><td>54</td><td>50</td><td>Full</td><td>full</td><td>full</td><td>full</td><td>full</td><td></td></tr>
</table>

Range of Motion – 3 Month Assessment (Raw Data)

Active Range

Participant	Shoulder Abduction (Range = 0 - 180°)	Shoulder Flexion (Range = 0 - 180°)	Shoulder Internal rotation (Range = 0 - 90°)	Shoulder External rotation (Range = 0 - 90°)	Elbow Flexion (Range = 0 - 150°)	Elbow Extension (0°)	Forearm supination (Range = 0 - 80° - 90°)	Forearm Pronation (Range = 0 - 80° - 90°)	Wrist Flexion (Range = 0 - 80°)
1	90	-10	full	Full	full	160	90	full	full
2	180	180	90	90	150	0	100	90	80
3	180	180	90	0	150	0	90	90	80
4	180	180	NT	NT	150	NT	0	90	80
5	full	full	full	Full	full	full	full	full	full
6	180	180	90	90	150	0	90	90	80

Active Range Continued

Participant	Wrist Extension (Range = 0 - 70°)	Ulnar Deviation (Range = 0 - 30°)	Radial Deviation (Range = 0 - 20°)	Finger Flexion	Finger Extension	Thumb Flexion	Thumb Extension	Thumb Abduction	
1	0	30	0	Full	full	Limited (no measure)	full	full	
2	80	48	0	Full	full	full	full	full	
3	32	0	0	Full	full	full	full	full	
4	0	0	0	Full	full	0	0	0	
5	68	12	full	Full	full	full	full	full	
6	70	30	20	Full	full	full	full	full	

Range of Motion – 3 Month Assessment (Raw Data)

Passive Range									
Participant	**Shoulder Abduction (Range = 0 - 180°)**	**Shoulder Flexion (Range = 0 - 180°)**	**Shoulder Internal rotation (Range = 0 - 90°)**	**Shoulder External rotation (Range = 0 - 90°)**	**Elbow Flexion (Range = 0 - 150°)**	**Elbow Extension (0°)**	**Forearm supination (Range = 0 - 80° - 90°)**	**Forearm Pronation (Range = 0 - 80° - 90°)**	**Wrist Flexion (Range = 0 - 80°)**
1	full	full	full	Full	full	170	full	full	full
2	180	180	90	90	150	0	90	90	80
3	180	180	90	90	150	0	90	90	80
4	180	180	90	90	150	0	90	90	80
5	full	full	full	Full	full	full	full	full	full
6	180	180	90	90	150	0	90	90	80

Passive Range Continued									
Participant	**Wrist Extension (Range = 0 - 70°)**	**Ulnar Deviation (Range = 0 - 30°)**	**Radial Deviation (Range = 0 - 20°)**	**Finger Flexion**	**Finger Extension**	**Thumb Flexion**	**Thumb Extension**	**Thumb Abduction**	
1	full	full	full	Full	full	full	full	full	
2	70	30	32	Full	full	full	full	full	
3	70	30	20	Full	full	full	full	full	
4	38	30	20	Full	full	full	full	full	
5	full	full	full	Full	full	full	full	full	
6	70	30	20	Full	full	full	full	full	

Grip Strength
Pre Assessment, Post-Assessment, 3-Month Assessment (Raw Data)

	Pre-Assessment					
	Affected Arm			**Unaffected Arm**		
Participant	*Trial 1*	*Trial 2*	*Trial 3*	*Trial 1*	*Trial 2*	*Trial 3*
1	2	1.5	2	5	5	4.5
2	0	1	1	4	5	4.5
3	0	1	0	1.5	2.5	2.5
4	no try	no try	no try	4	4.25	4
5	2.5	3	2	4.5	5	5
6	2	2.5	3.5	4.5	5	4.5
	Post-Assessment					
	Affected Arm			**Unaffected Arm**		
Participant	*Trial 1*	*Trial 2*	*Trial 3*	*Trial 1*	*Trial 2*	*Trial 3*
1	1.5	0	1.5	4	4.5	4.5
2	0	0	0	3.5	3.5	4.5
3	1	1.5	1.5	4	4	3.5
4	0	0	0	4	4	4
5	2.5	2	2	4	4	4
6	4	2.5	2	5	6	5.5
	3-Month Assessment					
	Affected Arm			**Unaffected Arm**		
Participant	*Trial 1*	*Trial 2*	*Trial 3*	*Trial 1*	*Trial 2*	*Trial 3*
1	NT	NT	NT	NT	NT	NT
2	1.5	1	1	5	5.5	5
3	1.25	2	2	4	4	3
4	0.5	0	0	4	5	4
5	2.5	2	3	4	3.5	4
6	3.5	3	2.5	6	5.5	5.5

Grandview Questionnaire for Parents
Pre-Assessment (Raw Data)

	PERFORMANCE						
Participant	**Frequency of Use**	**Spontaneity of Use**	**Quality of Grasp (Gross)**	**Quality of Grasp (Precision)**	**Feeding**	**Toileting**	**Dressing**
1	5	6	4	3	7	8	1
2	8	9	7	7	10	9	2
3	3	5	2	2	10	7	5
4	3	4	6	3	5	7	4
5	6	5	8	8	10	10	8
6	8	7	9	8	10	9	8

	IMPORTANCE						
Participant	**Frequency of Use**	**Spontaneity of Use**	**Quality of Grasp (Gross)**	**Quality of Grasp (Precision)**	**Feeding**	**Toileting**	**Dressing**
1	7	7	6	5	8	7	7
2	10	10	10	10	10	10	10
3	10	10	9	8	1	10	10
4	10	10	10	10	10	10	10
5	10	10	3	3	3	3	10
6	9	10	10	10	1	10	10

	SATISFACTION						
Participant	**Frequency of Use**	**Spontaneity of Use**	**Quality of Grasp (Gross)**	**Quality of Grasp (Precision)**	**Feeding**	**Toileting**	**Dressing**
1	9	7	7	7	7	9	7
2	8	9	7	7	10	9	2
3	5	5	4	4	10	4	3
4	6	4	6	5	6	7	5
5	7	7	10	10	10	10	10
6	8	8	9	7	10	9	7

Grandview Questionnaire for Parents
Post-Assessment (Raw Data)

	PERFORMANCE						
Participant	**Frequency of Use**	**Spontaneity of Use**	**Quality of Grasp (Gross)**	**Quality of Grasp (Precision)**	**Feeding**	**Toileting**	**Dressing**
1	6	6	5	5	7	9	7
2	7	7	7	5	10	7	1
3	3	3	3	2	2	4	3
4	6	5	8	4	8	6	7
5	5	4	10	10	10	10	10
6	8	8	7	8	10	9	9

	IMPORTANCE						
Participant	**Frequency of Use**	**Spontaneity of Use**	**Quality of Grasp (Gross)**	**Quality of Grasp (Precision)**	**Feeding**	**Toileting**	**Dressing**
1	7	7	7	7	9	9	9
2	10	10	10	10	10	10	10
3	6	7	7	5	6	6	7
4	10	10	10	10	10	10	10
5	10	8	10	10	10	10	10
6	10	10	10	10	10	10	10

	SATISFACTION						
Participant	**Frequency of Use**	**Spontaneity of Use**	**Quality of Grasp (Gross)**	**Quality of Grasp (Precision)**	**Feeding**	**Toileting**	**Dressing**
1	8	8	8	8	7	10	8
2	7	7	7	5	10	7	1
3	3	3	4	2	3	3	3
4	5	6	8	5	8	6	4
5	10	10	10	10	10	10	10
6	8	9	8	8	10	9	10

Grandview Questionnaire for Parents
3-Month Assessment (Raw Data)

	PERFORMANCE						
Participant	**Frequency of Use**	**Spontaneity of Use**	**Quality of Grasp (Gross)**	**Quality of Grasp (Precision)**	**Feeding**	**Toileting**	**Dressing**
1	7	7	4	6	8	8	4
2	10	10	10	6	10	10	6
3	4	3	4	2	9	4	3
4	4	2	7	2	10	7	6
5	8	8	10	10	10	10	10
6	7	7	8	8	10	10	8

	IMPORTANCE						
Participant	**Frequency of Use**	**Spontaneity of Use**	**Quality of Grasp (Gross)**	**Quality of Grasp (Precision)**	**Feeding**	**Toileting**	**Dressing**
1	7	7	7	7	7	7	7
2	10	10	10	10	10	10	10
3	9	9	10	8	5	10	10
4	10	8	9	8	10	10	10
5	10	10	10	10	10	10	10
6	10	10	10	10	10	10	10

	SATISFACTION						
Participant	**Frequency of Use**	**Spontaneity of Use**	**Quality of Grasp (Gross)**	**Quality of Grasp (Precision)**	**Feeding**	**Toileting**	**Dressing**
1	7	7	5	5	7	7	5
2	10	10	10	6	10	10	6
3	4	3	4	3	8	5	5
4	5	5	5	3	10	6	5
5	10	10	10	10	10	10	10
6	8	8	8	8	10	8	6

Grandview Questionnaire for Camp Counselors (PERFORMANCE SECTION ONLY)
Pre-Assessment (Raw Data)

	Counselor 1						
Participant	**Frequency of Use**	**Spontaneity of Use**	**Quality of Grasp (Gross)**	**Quality of Grasp (Precision)**	**Feeding**	**Toileting**	**Dressing**
1	5	2	5	2	2	n/a	3
2	7	7	4	4	6	n/a	3
3	2	2	3	2	2	n/a	2
4	2	1	2	1	1	n/a	1
5	7	6	5	5	8	n/a	6
6	4	6	6	6	4	3	3

	Counselor 2						
Participant	**Frequency of Use**	**Spontaneity of Use**	**Quality of Grasp (Gross)**	**Quality of Grasp (Precision)**	**Feeding**	**Toileting**	**Dressing**
1	5	5	6	5	5	5	5
2	6	5	6	4	5	n/a	5
3	2	2	2	1	2	2	2
4	1	1	2	2	1	2	2
5	7	7	8	7	8	6	6
6	6	6	7	6	6	6	5

	Counselor 3						
Participant	**Frequency of Use**	**Spontaneity of Use**	**Quality of Grasp (Gross)**	**Quality of Grasp (Precision)**	**Feeding**	**Toileting**	**Dressing**
1	4	4	6	5	6	6	6
2	4	4	5	4	5	5	4
3	4	3	3	2	2	2	2
4	1	1	3	2	2	3	3
5	7	8	7	6	7	7	7
6	5	5	4	4	6	6	6

Grandview Questionnaire for Camp Counsellors (PERFORMANCE SECTION ONLY)
Pre-Assessment (Average Counsellor Score)

	A						
Participant	**Frequency of Use**	**Spontaneity of Use**	**Quality of Grasp (Gross)**	**Quality of Grasp (Precision)**	**Feeding**	**Toileting**	**Dressing**
1	4.67	3.67	5.67	4.00	4.33	5.50	4.67
2	5.67	5.33	5.00	4.00	5.67	5.00	4.00
3	2.67	2.33	2.67	1.67	2.00	2.00	2.00
4	1.33	1.00	2.33	1.67	1.33	2.50	2.00
5	7.00	7.00	6.67	6.00	7.67	6.50	6.33
6	5.00	5.67	5.67	5.33	5.33	5.00	4.67

Grandview Questionnaire for Camp Counselors (PERFORMANCE SECTION ONLY)
Post-Assessment (Raw Data)

	Counselor 1						
Participant	**Frequency of Use**	**Spontaneity of Use**	**Quality of Grasp (Gross)**	**Quality of Grasp (Precision)**	**Feeding**	**Toileting**	**Dressing**
1	7	6	7	6	7	n/a	7
2	9	9	7	7	7	n/a	7
3	7	6	5	4	4	n/a	4
4	6	6	4	2	3	n/a	3
5	9	9	8	8	9	n/a	8
6	9	9	7	7	7	n/a	6

	Counselor 2						
Participant	**Frequency of Use**	**Spontaneity of Use**	**Quality of Grasp (Gross)**	**Quality of Grasp (Precision)**	**Feeding**	**Toileting**	**Dressing**
1	7	6	8	8	8	n/a	n/a
2	8	8	8	7	7	n/a	n/a
3	7	6	5	3	5	n/a	n/a
4	5	4	5	3	5	n/a	n/a
5	9	9	9	9	8	7	6
6	8	8	8	8	7	n/a	6

	Counselor 3						
Participant	**Frequency of Use**	**Spontaneity of Use**	**Quality of Grasp (Gross)**	**Quality of Grasp (Precision)**	**Feeding**	**Toileting**	**Dressing**
1	7	8	7	9	10	8	9
2	8	9	7	8	9	8	7
3	7	9	6	7	8	7	7
4	7	7	6	6	6	6	6
5	8	9	10	10	10	8	9
6	10	10	9	9	10	9	9

Grandview Questionnaire for Camp Counsellors (PERFORMANCE SECTION ONLY)
Post-Assessment (Average Counsellor Score)

	Average Counsellor Score by Section						
Participant	**Frequency of Use**	**Spontaneity of Use**	**Quality of Grasp (Gross)**	**Quality of Grasp (Precision)**	**Feeding**	**Toileting**	**Dressing**
1	7.00	6.67	7.33	7.67	8.33	8.00	8.00
2	8.33	8.67	7.33	7.33	7.67	8.00	7.00
3	7.00	7.00	5.33	4.67	5.67	7.00	5.50
4	6.00	5.67	5.00	3.67	4.67	6.00	4.50
5	8.67	9.00	9.00	9.00	9.00	7.50	7.67
6	9.00	9.00	8.00	8.00	8.00	9.00	7.00

TPOCS-A Total Scores and TPOCS-A Quality of Session Scores for Each Participant

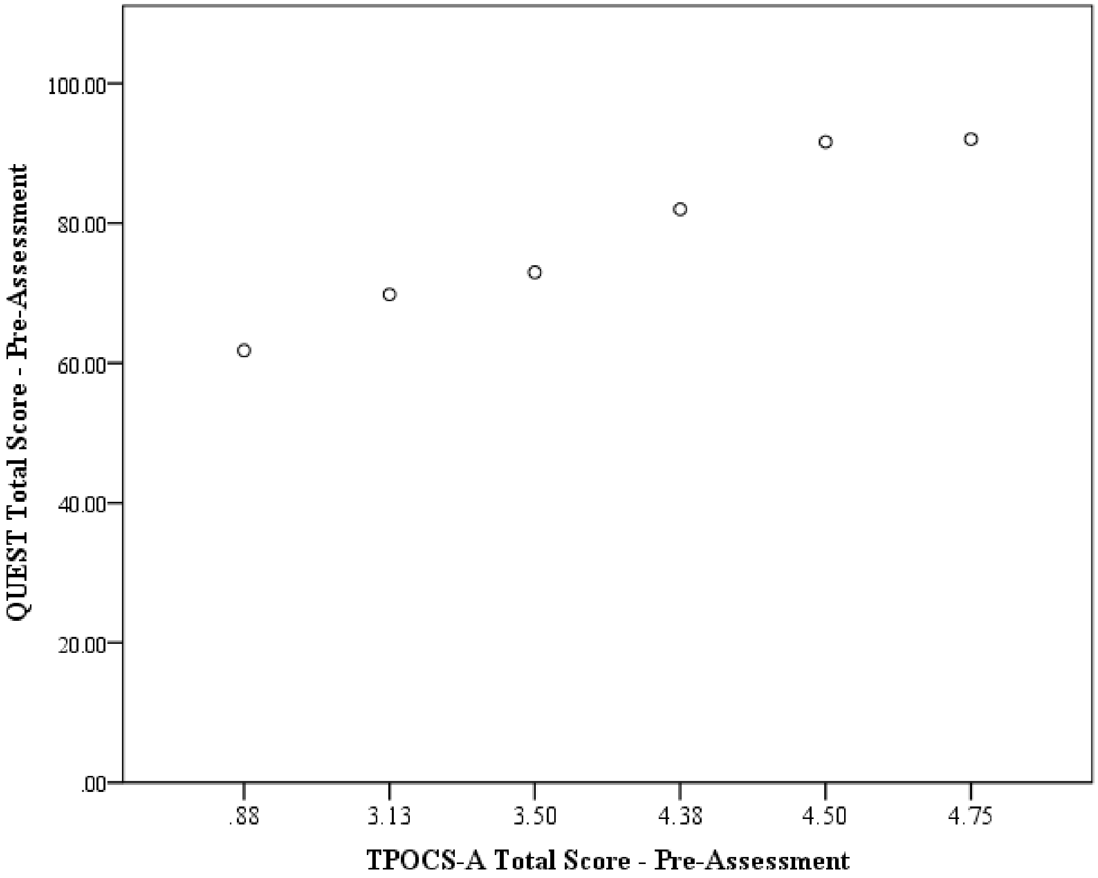
Pre-Assessment, Post-Assessment, and 3 Month Follow-up Scores

	TPOCS-A Total Scores		
	Pre-Assessment	**Post-Assessment**	**3-Month Follow up**
Participant 1	3.5	1.63	1.13
Participant 2	4.38	4.75	4.63
Participant 3	3.13	1.88	2.88
Participant 4	0.88	0.25	0.38
Participant 5	4.75	4.13	5
Participant 6	4.5	4.75	5

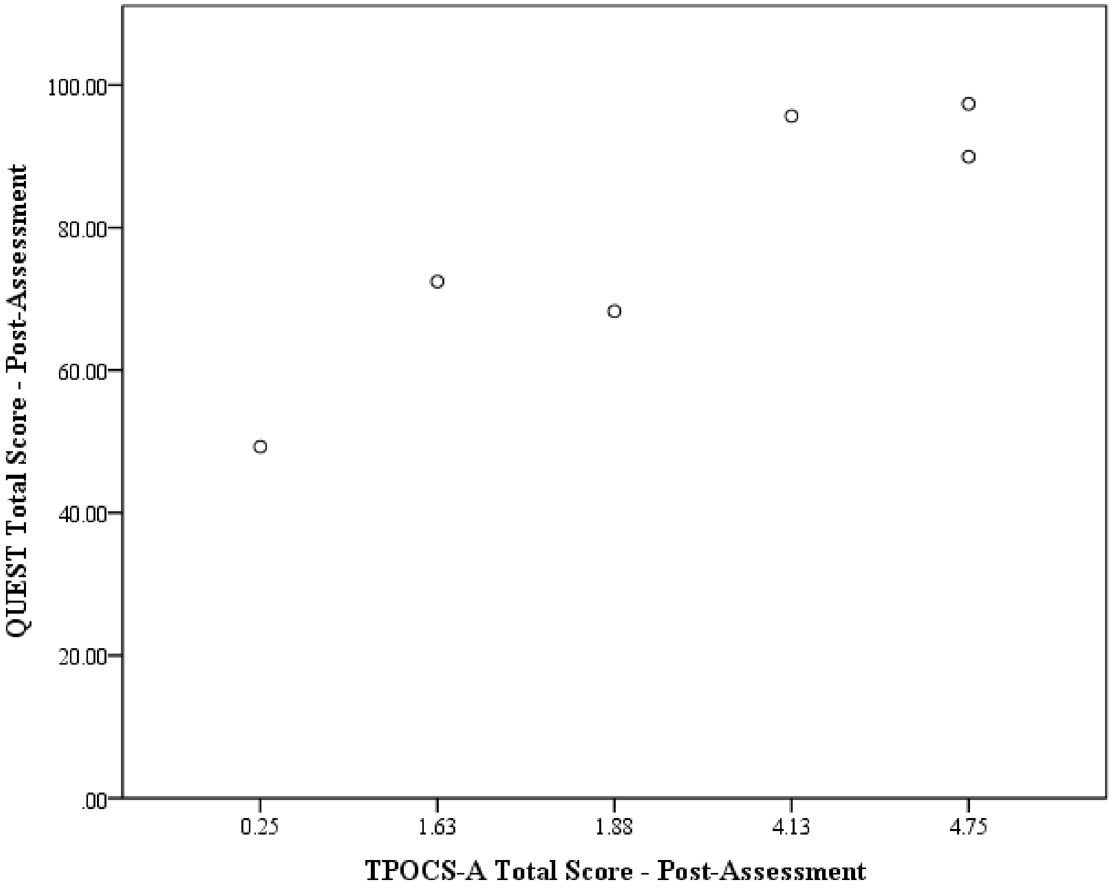
	Quality of Session Scores		
	Pre-Assessment	**Post-Assessment**	**3-Month Follow up**
Participant 1	5.25	4.5	4.5
Participant 2	7	7	6.5
Participant 3	5.5	5.75	6.5
Participant 4	3.75	3.5	4
Participant 5	7	6.75	6.75
Participant 6	6.75	7	7

Appendix 9: Scatterplots demonstrating the relationship between total TPOCS-A scores and total QUEST scores (out of 100) at (a) the pre-assessment session (b) the post-assessment session, and (c) the 3-month follow up session (each point represents one participant).

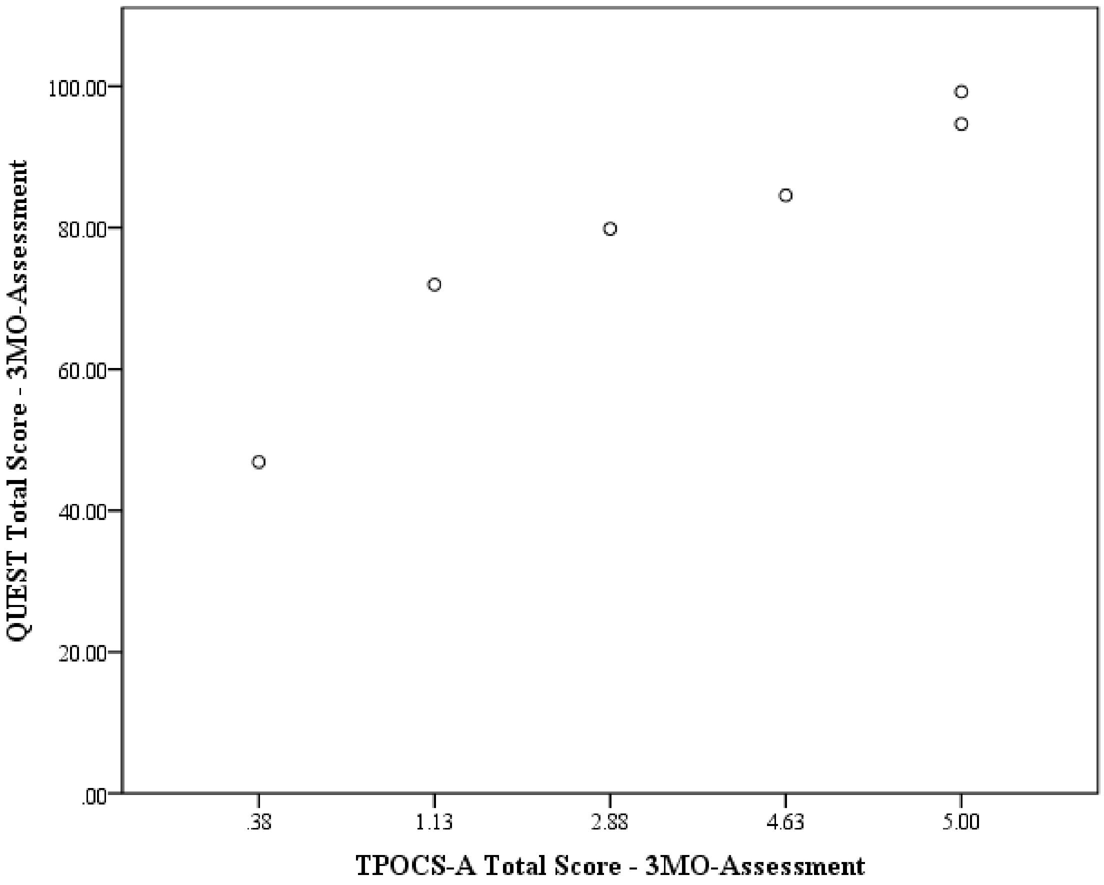
(a)



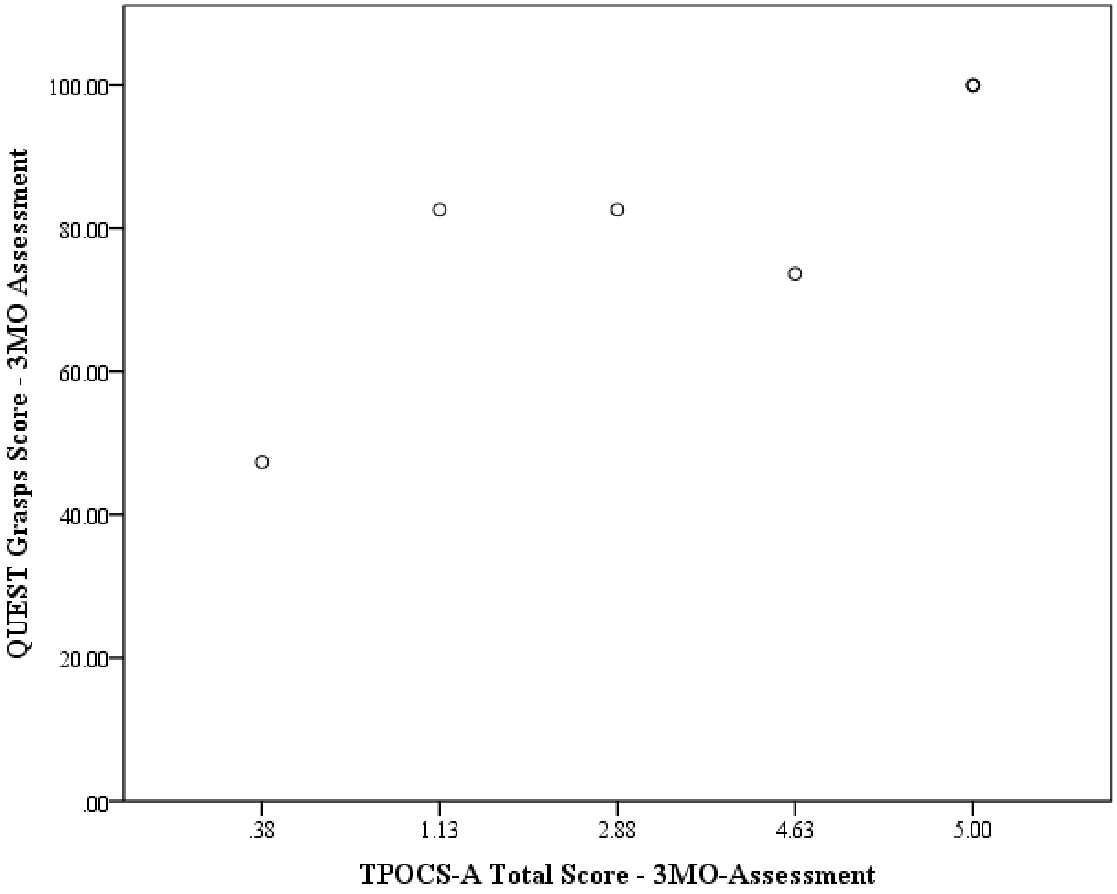
(b)


100.00
80.00
60.00
40.00
20.00
.00
0.25
1.63
1.88
4.13
4.75
QUEST Total Score - Post-Assessment
TPOCS-A Total Score - Post-Assessment

(c)

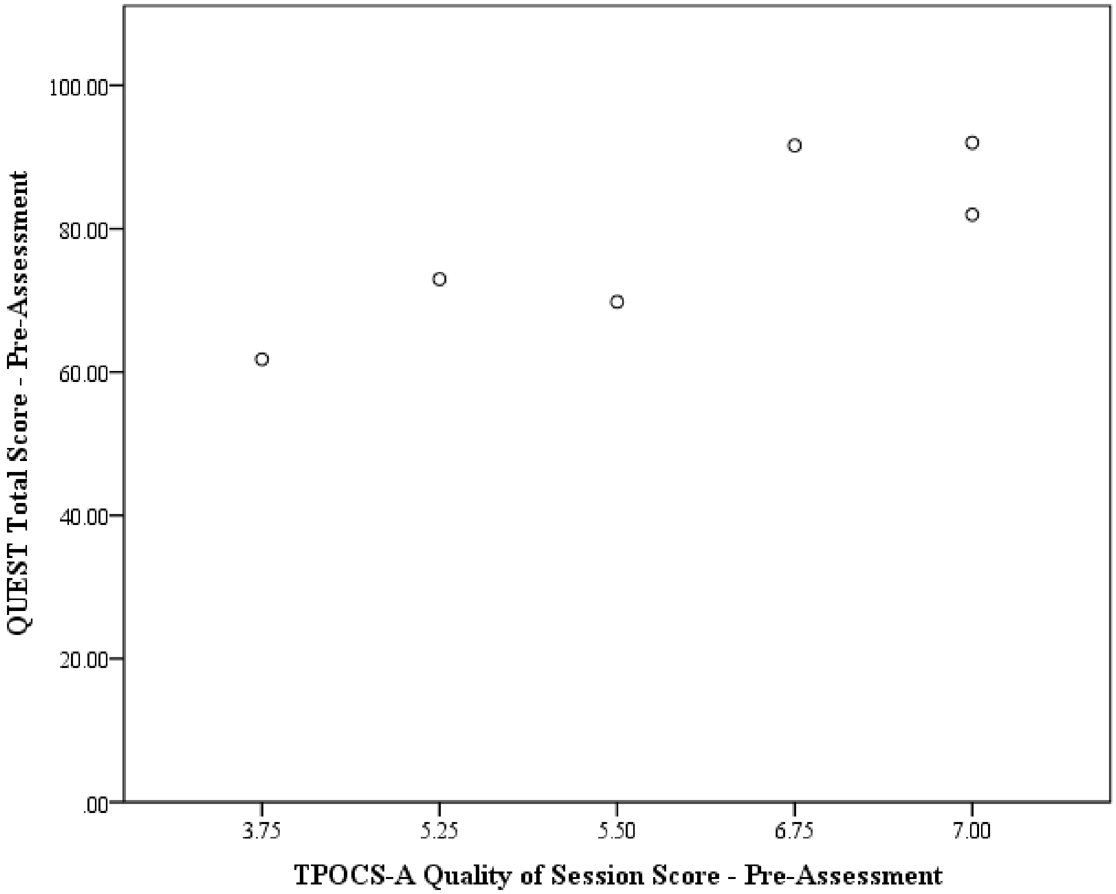

100.00
80.00
60.00
40.00
20.00
.00
QUEST Total Score - 3MO-Assessment
.38
1.13
2.88
4.63
5.00
TPOCS-A Total Score - 3MO-Assessment

Appendix 10: Scatterplot demonstrating relationship between total TPOCS-A scores and scores on Grasps sub-sections of QUEST at the 3-month follow-up assessment

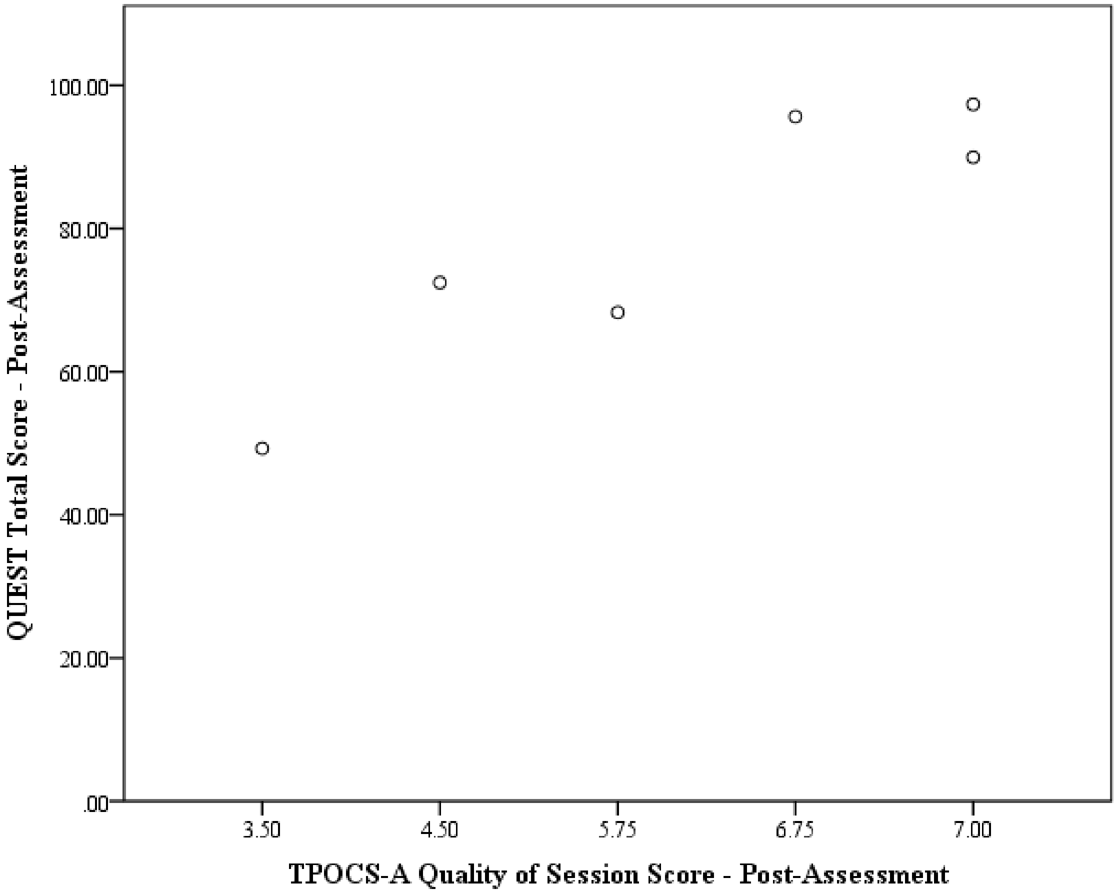


Appendix 11: Scatterplots demonstrating the relationship between TPOCS-A quality of session scores and total QUEST score at (a) the pre-assessment ($r(6)=0.967$, $p<0.01$), (b) the post-assessment ($r(6)=0.929$, $p<0.01$), and (c) the 3-month follow-up ($r(6)=0.916$, $p=0.01$). Note: Each point represents one participant.

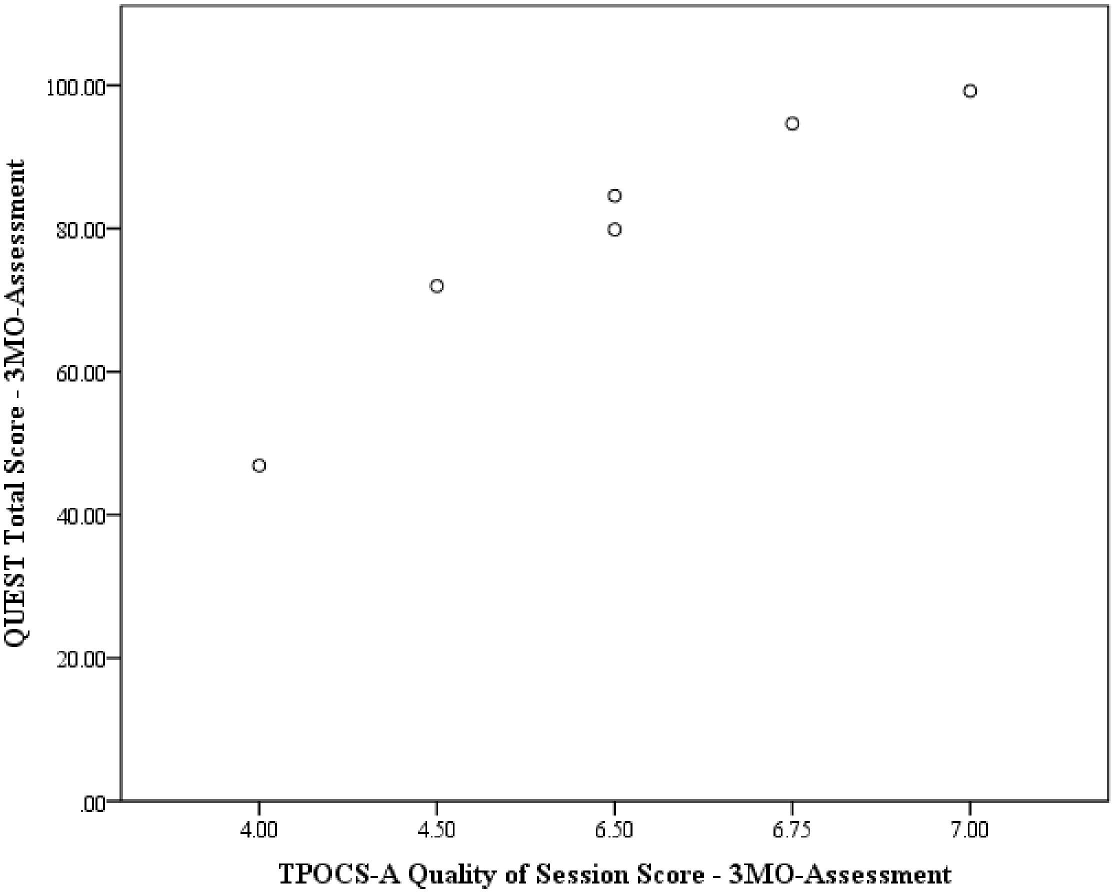
(a)



(b)

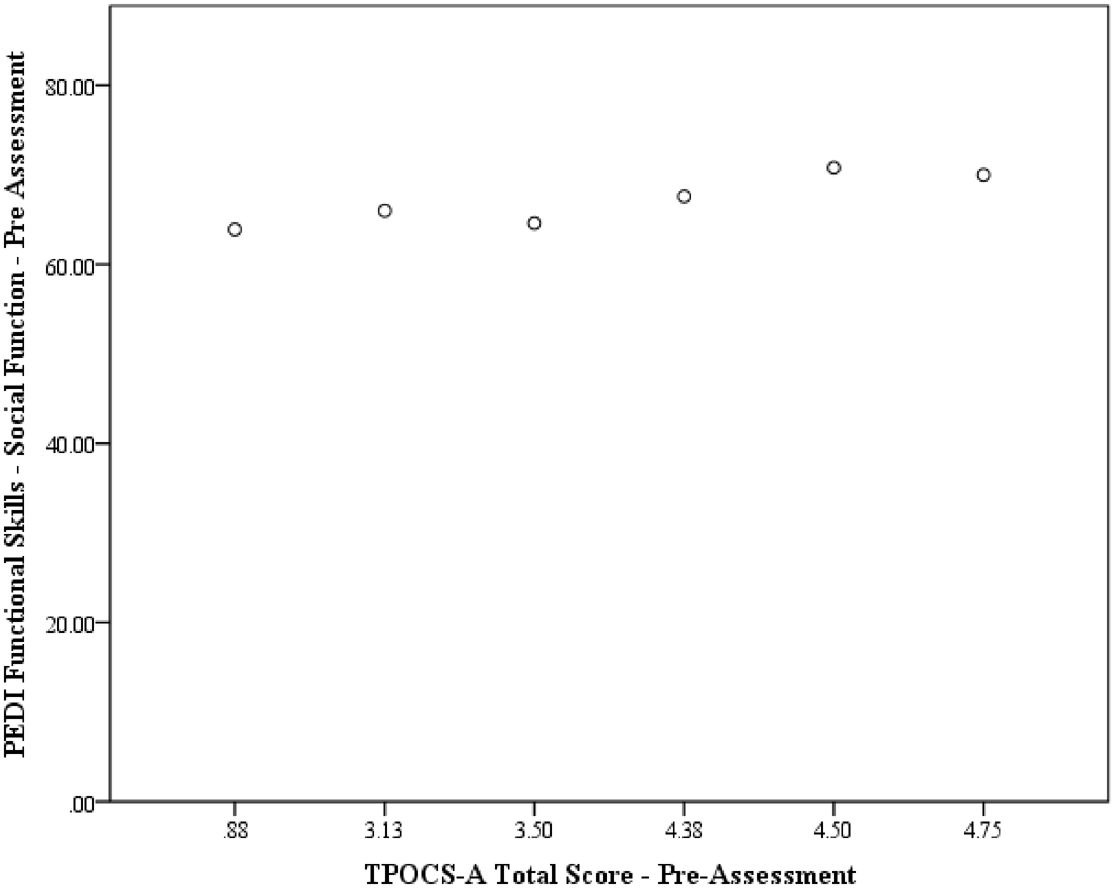

100.00
80.00
60.00
40.00
20.00
.00
QUEST Total Score - Post-Assessment
3.50
4.50
5.75
6.75
7.00
TPOCS-A Quality of Session Score - Post-Assessment

(c)

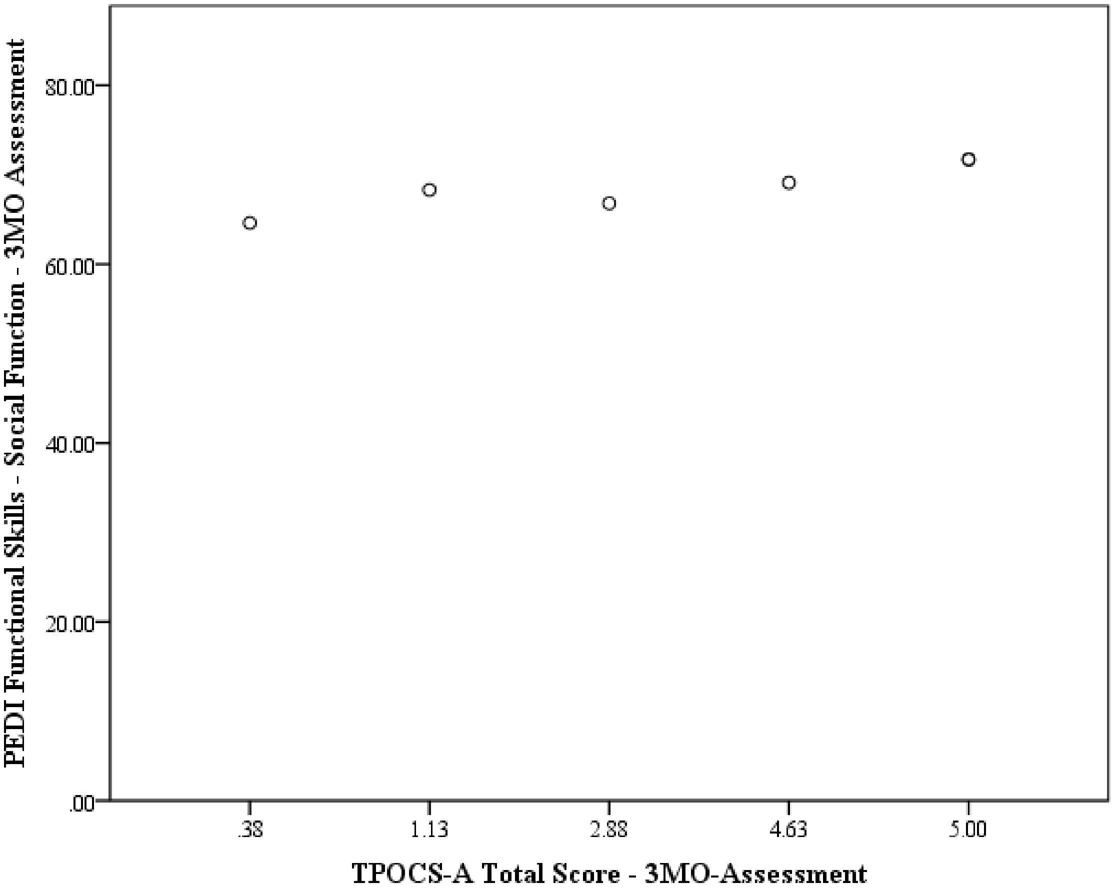

100.00
80.00
60.00
40.00
20.00
.00
QUEST Total Score - 3MO-Assessment
4.00
4.50
6.50
6.75
7.00
TPOCS-A Quality of Session Score - 3MO-Assessment

Appendix 12: Scatterplots demonstrating the relationship between (a) total TPOCS-A scores and scores on social function sub-section of Functional Skills section of PEDI at pre-assessment, (b) total TPOCS-A scores and scores on social function sub-section of Functional Skills section of PEDI at the 3-month follow-up session, and (c) TPOCS-A quality of session scores and scores on social function sub-section of Functional Skills section of PEDI at the pre-assessment session.

(a)

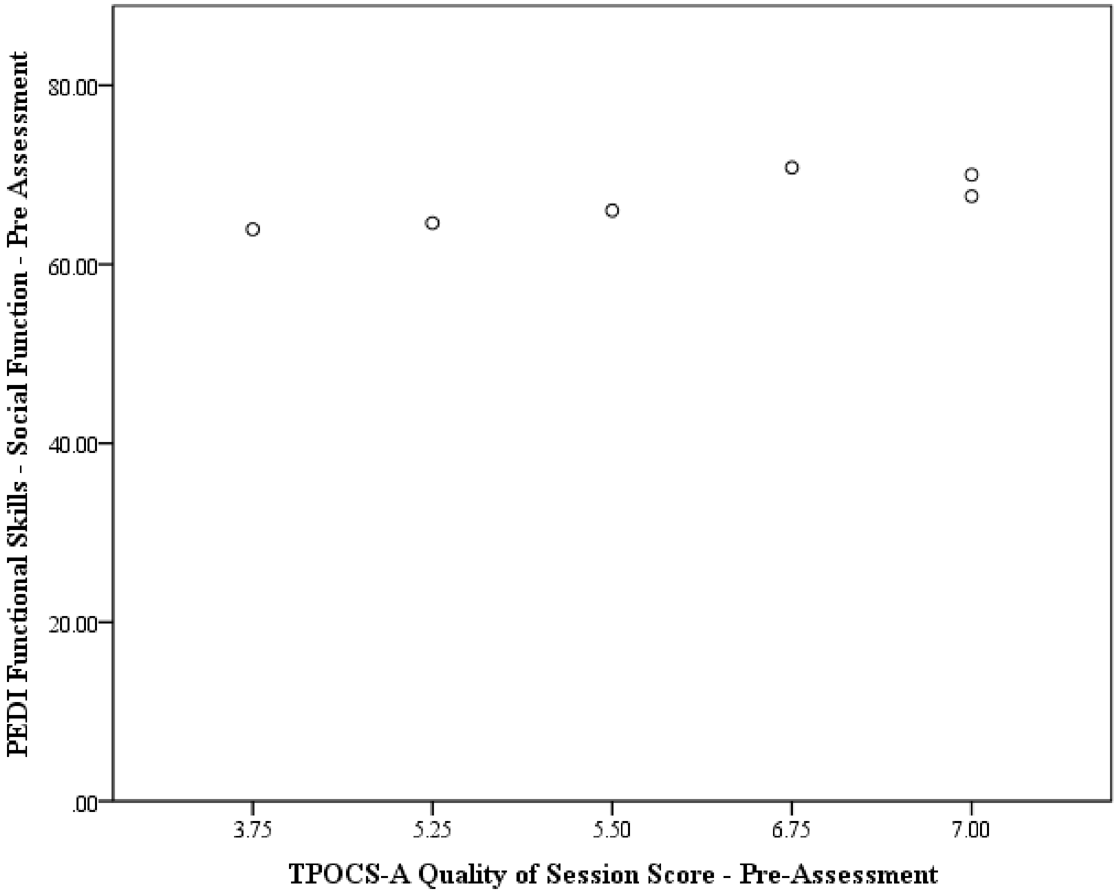


(b)



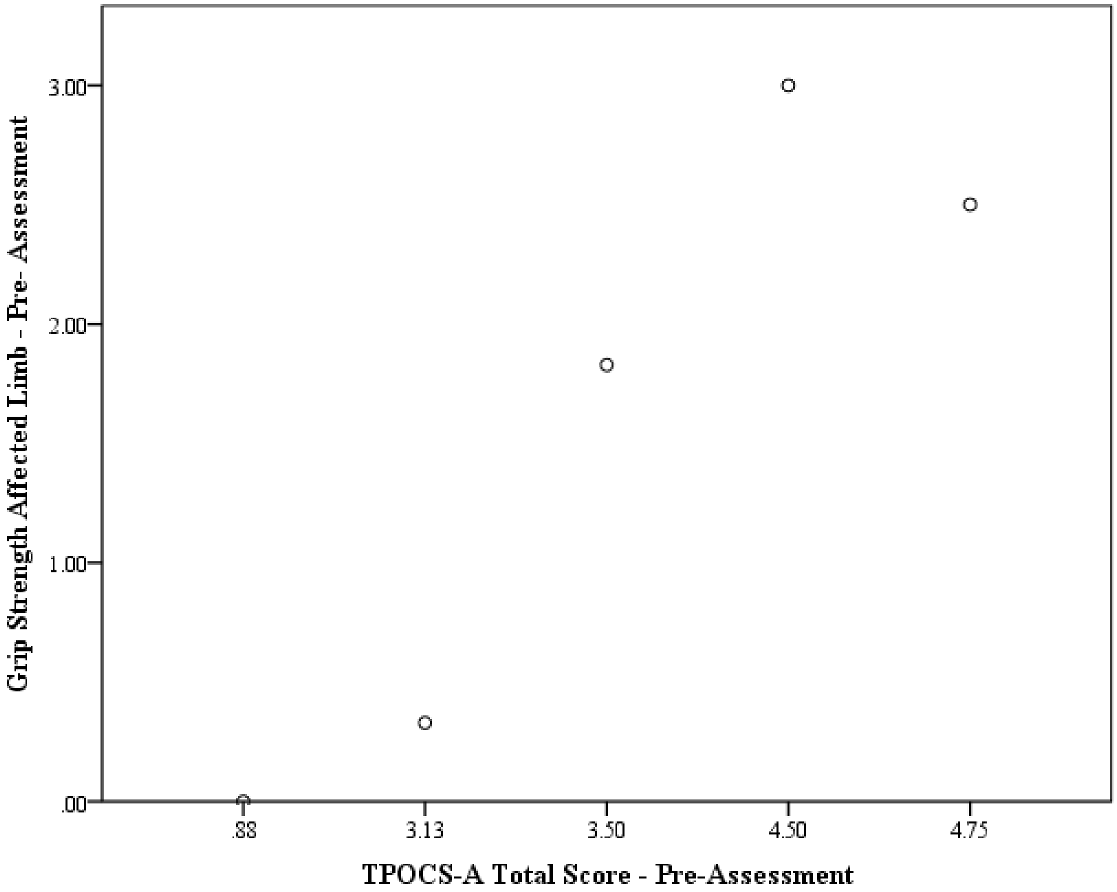
80.00
60.00
40.00
20.00
.00
.38
1.13
2.88
4.63
5.00
PEDI Functional Skills - Social Function - 3MO Assessment
TPOCS-A Total Score - 3MO-Assessment

(c)

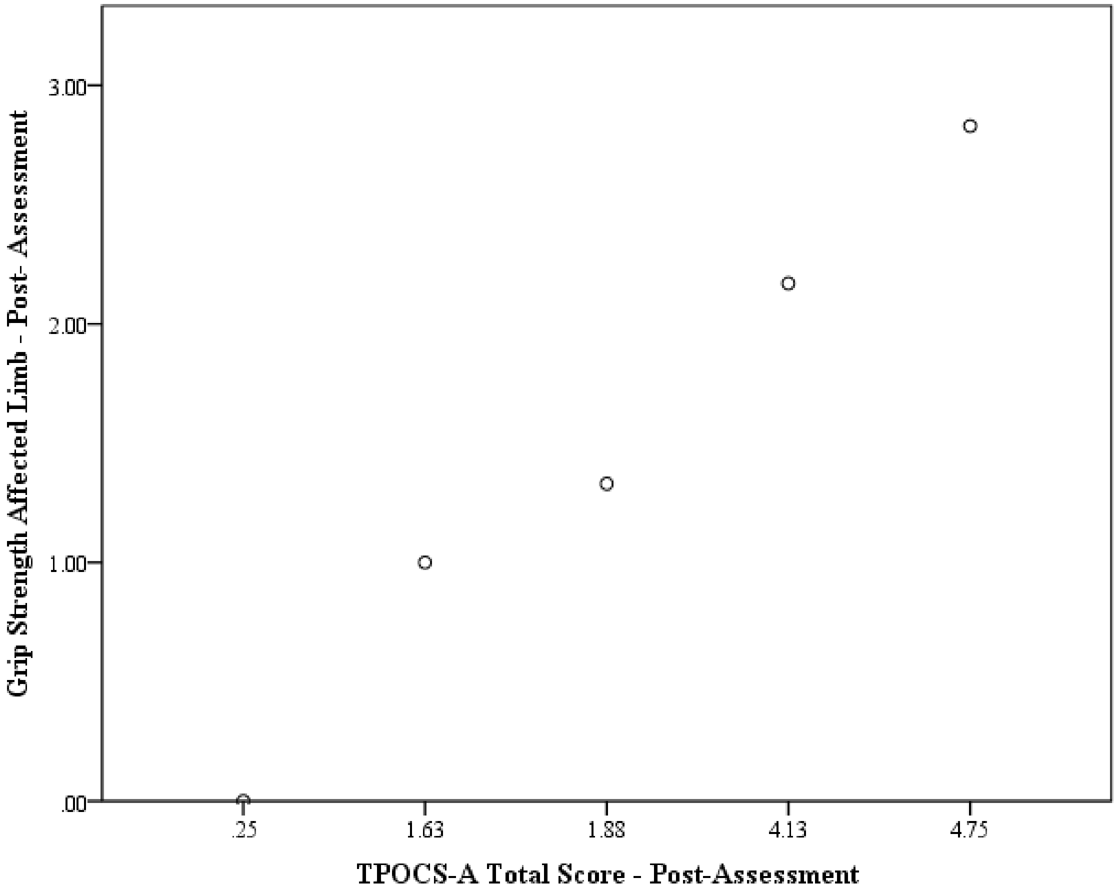

PEDI Functional Skills - Social Function - Pre Assessment
80.00
60.00
40.00
20.00
.00
3.75
5.25
5.50
6.75
7.00
TPOCS-A Quality of Session Score - Pre-Assessment

Appendix 13: Scatterplots demonstrating the relationship between total TPOCS-A scores and grip strength in the affected limb at (a) the pre-assessment session, (b) the post assessment session, and (c) the 3-month follow-up session (Note: Participant 2's data are excluded; correlations at all three assessment sessions reached statistical significance).

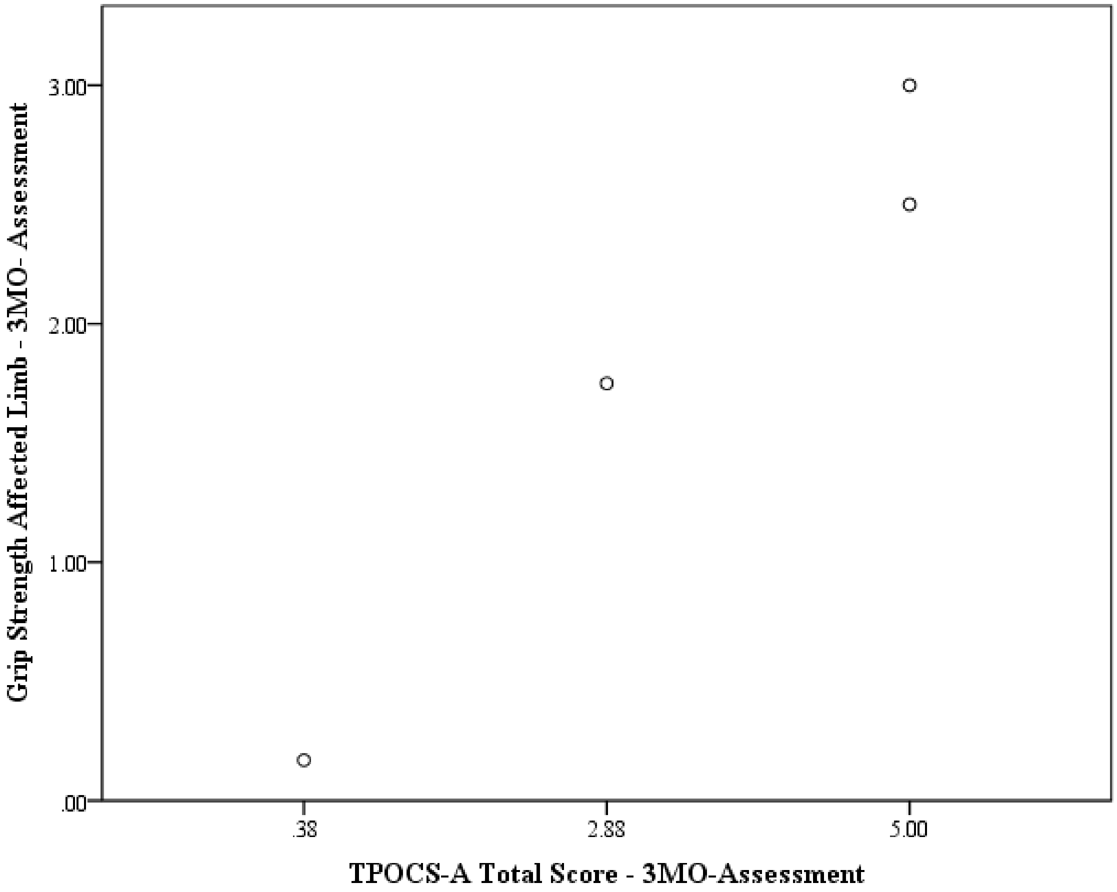
(a)



(b)


3.00
2.00
1.00
.00
Grip Strength Affected Limb - Post- Assessment
.25
1.63
1.88
4.13
4.75
TPOCS-A Total Score - Post-Assessment

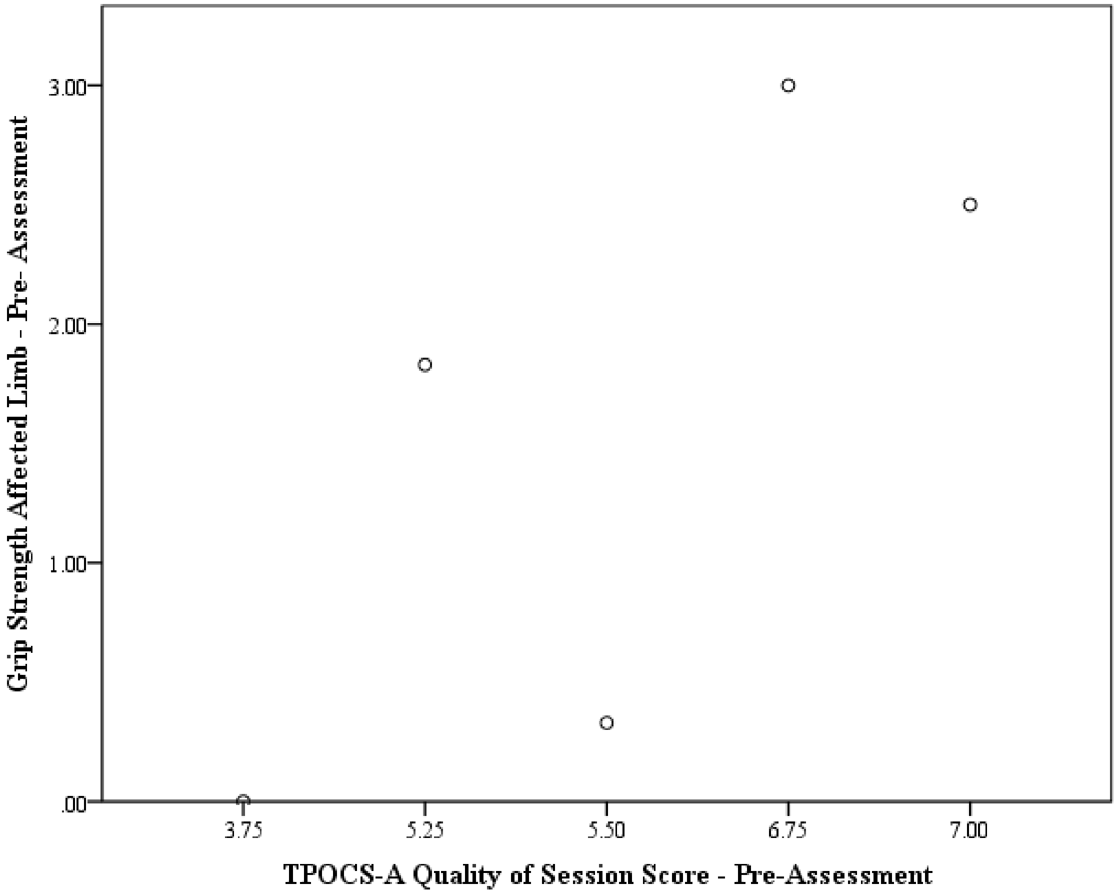
(c)



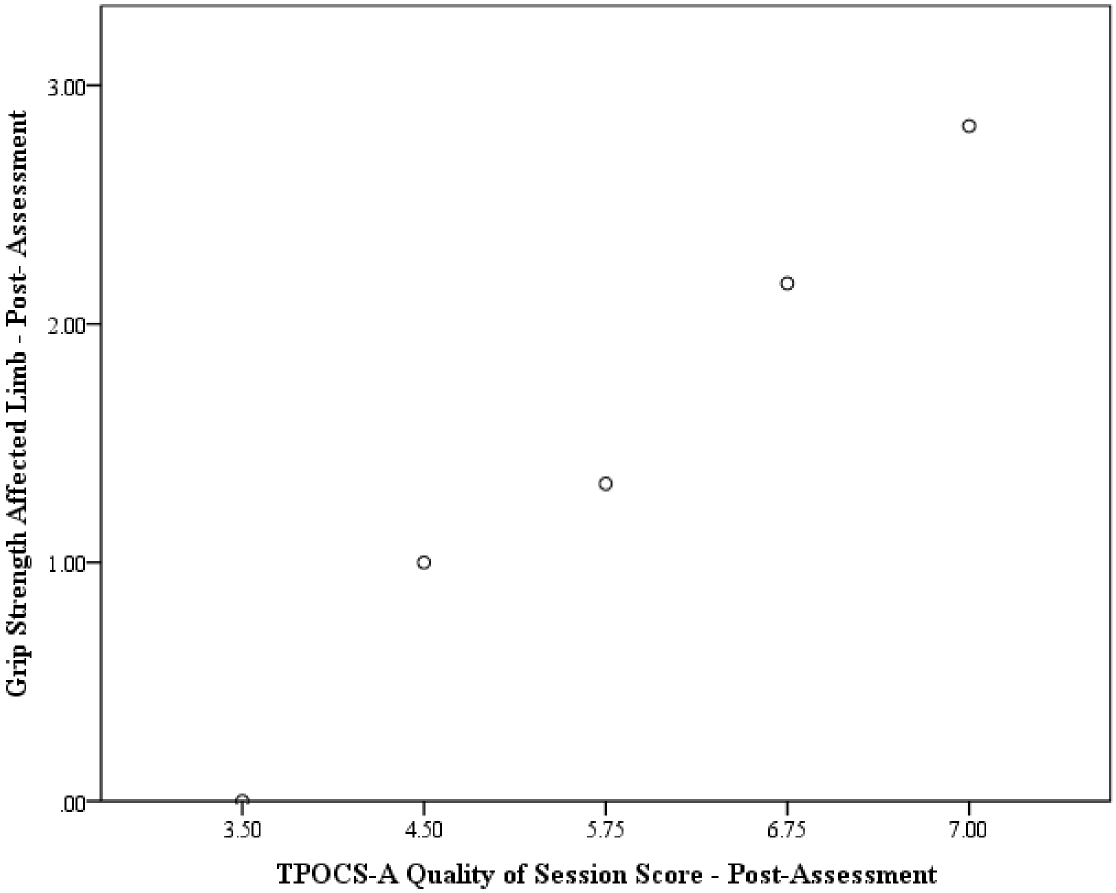
*** Participant 1 not tested at 3-month follow-up assessment**

Appendix 14: Scatterplots demonstrating the relationship between TPOCS-A quality of session scores and grip strength at (a) the pre-assessment, (b) the post-assessment, and (c) the 3 month follow-up (Note: Participant 2's data are excluded, and only the post-assessment and 3-month follow-up assessment correlations reached significance)

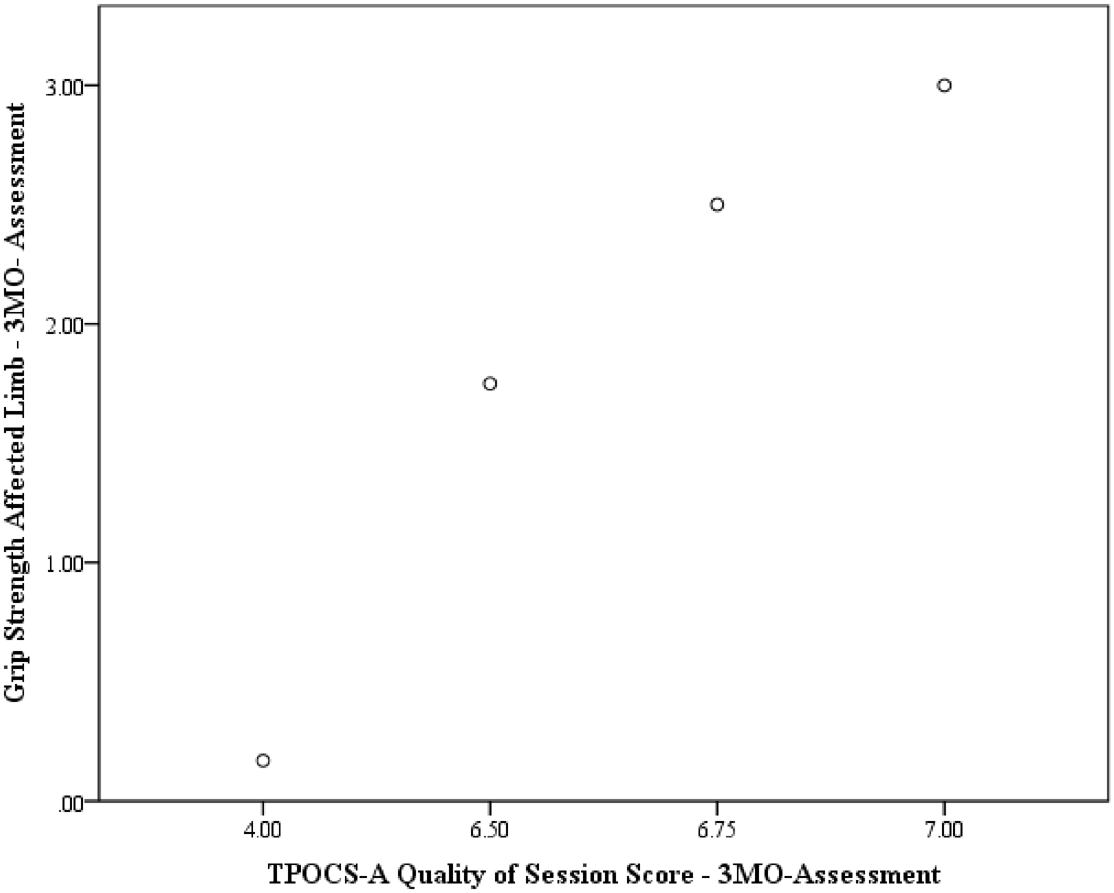
(a)



(b)


3.00
2.00
1.00
.00
Grip Strength Affected Limb - Post- Assessment
3.50
4.50
5.75
6.75
7.00
TPOCS-A Quality of Session Score - Post-Assessment

(c)



***Note: Participant 1 not tested at 3-month follow-up**