Case Report: *ICF*-Level Changes in a Preschooler After Constraint-Induced Movement Therapy

Anna Martin, Patricia A. Burtner, Janet Poole, John Phillips

The authors examined changes associated with constraint-induced movement therapy (CIMT) provided to a preschool-aged child with right spastic hemiplegia. This case study design used a 2-week pretest measure baseline period, 2 weeks of CIMT, and postmeasures at 1 week and 3 months. Measures were chosen to document changes at the different levels of *International Classification of Functioning, Disability and Health (ICF)*, including the Canadian Occupational Performance Measure (COPM), Pediatric Evaluation of Disability Inventory (PEDI) Self-Care Section, Melbourne Assessment of Unilateral Upper Limb Function, and grip and pinch strength. Results showed increases on COPM-identified goals of increased independence with bilateral hand play and participation in gross motor play with friends. Changes were also documented in self-care, arm function, and grip strength. Another unexpected association reported by parents and professionals was increased speech intelligibility. Potential implications of implementing CIMT with young children are presented.


**Cerebral palsy (CP)** is a motor disorder resulting from a nonprogressive lesion to the motor cortex during the early period of development. People with spastic hemiplegic CP have decreased motor control and increased spasticity on one side of the body; the arm is typically more affected than the leg (Pellegrino, 2002). Cerebral palsy often has pervasive effects on children and can affect all levels of the World Health Organization’s *International Classification of Functioning, Disability and Health (ICF)*; World Health Organization, 2001). Because of the international and interdisciplinary focus of the *ICF* framework, the American Academy of Cerebral Palsy and Developmental Medicine (2007), an international professional organization, recognizes the WHO framework as a common language format within its official treatment outcomes publications supporting evidence-based practice for this population of children. Interventions for children with CP may include neuropharmacologic treatment, orthopedic surgery, serial casting and splinting, and occupational and physical therapy. More recently, constraint-induced movement therapy (CIMT; Taub, Ramey, DeLuca, & Echols, 2004) has been introduced as a therapeutic intervention for children with hemiplegic CP.

CIMT was first examined clinically in adults after stroke, spinal cord injury, or other neurologic disorders. After constraint of the less-involved limb and repetitive mass practice of upper-extremity skills with the more involved arm, the adults showed increased functional use of the impaired upper extremity and reversal of learned nonuse (for a review, please see Mark & Taub, 2002). Although fewer studies document outcomes of CIMT in children with hemiplegic CP, current findings suggest promising increases in functional use of the affected arm (for extensive review, see Charles & Gordon, 2005). The main principles of the CIMT are twofold: (1) restraint of the child’s less-involved upper extremity and (2) inten-
sive practice of the hemiplegic arm and hand using shaping, a behavioral technique in which the task goal is approached in small steps through successive approximation while grading the task difficulty according to the child’s abilities and success (Gordon, Charles, & Wolf, 2005). More recently, Eliasson, Krumlinde-Sundholm, Shaw, and Wang (2005) introduced a modified version of CIMT for young children with adaptations of (1) restraint of the less-involved hand, fingers, or thumb in a stiff removable mitt and (2) intervention that is structured activity–based practice rather than shaping.

**Purpose**

Previous studies documenting changes in children with hemiplegic CP were not specifically designed to show changes at the multiple levels outlined in the ICF. The purpose of this case study was to explore changes associated with a CIMT trial on a child’s function at all ICF Levels of Activity and Participation and Body Structure and Function, as identified by (1) parent-identified occupation goals of participation and activities, (2) quality of upper-extremity movement, (3) performance of self-care skills, and (4) grip and pinch strength with a 3-year-old child. By measuring the child’s performance simultaneously at the different levels, the intent was to identify possible associations between body structure and function and activity and participation changes.

**Method**

**Participant**

One child with right hemiplegic spastic CP caused by a perinatal ischemic event was recruited to participate in this study. Because he was diagnosed with CP during the first year of life, he received early intervention services, including occupational, physical, and speech therapy services, through a local agency. At the time of admission to this study, he was 35 months old and had normal cognition on the Bayley Scales of Infant Development II (Bayley, 1993). To participate in the study, we chose inclusion criteria from previous adult research (Wolf et al., 2006) and one pediatric study (Charles, Wolf, Schneider, & Gordon, 2006) requiring the participants to have a minimum of 20° of active wrist extension and 10° of active finger extension in the hemiplegic hand (the participant had 30° of active wrist and approximately 20° of finger extension). Exclusion criteria were other neurologic impairments and orthopedic surgery or neuropharmacologic interventions such as botulinum toxin in the past 6 months. Sensory testing revealed intact sensation to light touch and stereognosis of common objects. Approval was received from the institutional review board at the university.

**Measures**

The following outcome measures were used: (1) Canadian Occupational Performance Measure (COPM; Law et al., 1998), (2) Melbourne Assessment of Unilateral Upper Limb Function (Johnson et al., 1994), (3) Self-Care Scale of the Pediatric Evaluation of Disability Inventory (PEDI; Haley, Coster, Ludlow, Haltiwanger, & Andrellos, 1992), (4) grip strength using calibrated Jamar hand dynamometer (Sammons Preston, Bolingbrook, IL; Mathiowetz, Wiemer, & Federman, 1986), (5) pinch strength using a calibrated B & L pinch gauge (North Coast Medical, Morgan Hill, CA; Mathiowetz et al., 1986), and (6) a qualitative interview form for parent report of observations of their child’s functional changes (e.g., hand use, activity level, speech) and psychosocial responses (e.g., tolerance to constraint, changes in sleep patterns, changes in emotional responses) during the CIMT trial. To accommodate for the child’s age, the grip and pinch meters were supported by the examiner on the table during testing. No adaptations were required for other measures.

**Procedures**

**Design.** This case study used an A1 (Baseline)–B (Intervention)–A2 (Post 1)–A3 (Post 2) design, spanning a 4.5-month time period. Clinical measures were administered four times during each measurement phase (baseline, Post 1, Post 2) except for the PEDI and COPM, which were administered one time at each measurement phase. Grip and pinch measures were taken three times to obtain a mean for each session. A bivalved removable cast that covered distal to the fingertips to the mid-upper arm was fabricated for the noninvolved arm.

**Intervention Phase.** During the intervention phase of the study, the participant was monitored daily for his ability to tolerate the cast. In addition, a general clinical research center (GCRC) nurse interviewed the family weekly as an external evaluator to compile qualitative data.

Intervention was provided in the child’s natural environments (home, preschool, swimming pool) by an occupational therapy graduate student research assistant supervised by a licensed occupational therapist for 4 hr per day, 6 days per week, for 2 weeks. The cast was worn on the nonhemiplegic arm for 4 hr of therapy and an additional 3 to 5 hr per day; the average wearing time was 7.31 hr per day. Two hours of therapy occurred in the participant’s home for early morning self-care skills and play, and 2 hr took place at the participant’s home, preschool, a therapy clinic, or therapeutic swimming pool.

The intervention was based on motor control and motor
learning principles as well as incorporating shaping strategies during daily occupations when the child was working individually with the research assistant. Motor control principles were emphasized by identifying and increasing active movement through the analysis of the degree of freedom of joint movements (Bernstein, 1967; Gordon, Charles, & Wolf, 2005) the child exhibited. On the basis of these principles, the Framework of Occupational Gradation for Children (C–FOG; Poole, Burtner, & Stockman, in press) was used as the framework of observation and intervention for upgrading and downgrading activities. Age-appropriate play and self-care activities for strengthening, fine motor coordination, and activities of daily living were emphasized.

Once specific movements were targeted for intervention, the therapeutic environment was adapted to promote the self-organized voluntary movement of the child during or through play. The child was challenged through the shaping process, practicing target movements in isolation of others (Gordon et al., 2005) to upgrade active motor control of the shoulder, arm, and hand during the activities, and repetitive task practice using motor learning principles of massed practice and transfer (Mathiowetz & Haugen, 1994; Schmidt & Wrisberg, 2000) were incorporated to reinforce the integration of motor skills. Play activities chosen for shaping were based on the C–FOG guidelines but also incorporated the child’s preferred activities that accomplished the same desired movements. For example, this child demonstrated decreased supination and massed grasp pattern on the C–FOG. During the self-care activity of bathing, this child began by scooping bath water in a plastic glass using supination and pouring it back in the water using pronation. Through shaping, this pattern was increased by incrementally aiming for a target container placed laterally to his hand, thus requiring increased supination during pouring. Target containers were large at first and decreased in size as the child developed more control in supination.

Other self-care skills that were gradually upgraded in difficulty using the hemiplegic extremity included brushing increasing numbers of his teeth with a spin brush, feeding himself finger foods for increasingprehension challenges, and taking off his socks and shirt with less assistance through shaping. Examples of strengthening activities were as follows: (1) manipulating larger to smaller objects hidden in play dough with shaping by increasing to different resistance levels of Theraputty (Sammons Preston, Bolingbrook, IL) and (2) increasing endurance while holding a paddleboard with hemiplegic arm and stabilizing the board on his other arm, which was in an air splint cast.

During sessions that were held at his preschool or in other group settings, the approach in intervention more closely approximated structured activity–based practice described by Eliasson, Krumlinde-Sundholm, Shaw, and Wang (2005), in which self-generated, voluntary actions are used and repeated in playful motivating settings. Play skills focused on his participation in play with the children in his preschool, such as using his affected arm to play a drum during music time, catching and throwing a ball in a group, playing with action figures in a group, and manipulating Mr. Potato Head (Hasbro Inc., Pawtucket, RI) pieces. The intervention emphasizes intense practice of tasks at the right level of difficulty while the child is intrinsically motivated to play.

Data Analysis. After all the data were collected, results were visually analyzed by graphing in Microsoft Excel and by comparing mean scores of all measures between pre- and posttest data sets (with the exception of the COPM and PEDI, which yielded one score at each data collection point).

Results

Changes in WHO ICF Levels of Activity and Participation

COPM. In the baseline phase of the study, the COPM was administered with two goals identified by the parent: (1) to increase coordination when compared with other children his age, particularly on the playground, and (2) to use both of his hands equally when playing. The mean COPM performance and satisfaction ratings of the identified goals are displayed in Figure 1. During the baseline phase, the mean rating of the child’s performance on the identified goals was 4 on a 10-point scale, whereas mean satisfaction was rated a 5. Immediately after intervention (Figure 1, Post 1), the mean ratings increased to 6.5 for the child’s performance and satisfaction. The greatest increase on the COPM goals were noted 3 months after intervention (Figure 1, Post 2) with
mean ratings by the parent of 7.5 on the child’s performance and 10 on parent satisfaction.

**PEDI.** In the baseline phase of the study, self-care domain of the PEDI, the participant scored 47 of a possible 73 points, as shown in Figure 2. The lower score on this scale reflected his need for assistance with pullover and front-opening garments, fasteners, pants, and shoes and socks, as well as in toileting tasks. Immediately after intervention (Figure 2, Post 1), the participant scored 53 of 73 points; the greatest increases occurred in the toileting tasks category. Three months after intervention (Figure 2, Post 2), he scored 63 of 73 points (large increases in shoes and socks and modest increases in fasteners, pants, and washing body and face). Although some changes could be attributed to maturation, many items were scored higher because of increased use of two hands during self-care. Interestingly, the participant’s score on the feeding portion of the PEDI decreased from baseline. When questioning the participant’s mother, she stated that she did not realize at the time of pretesting how little her son used his hemiplegic side, so she incorrectly rated him higher on an item requiring use of two hands.

**Other Qualitative Changes Reported in Activity and Participation.** The GCRC nurse documented other findings using a qualitative interview form during phone interviews with the mother throughout the study.

During the 1st week of intervention, the mother was surprised at how easily the child tolerated the cast on his nonaffected limb and reported no skin irritation or soreness. She noted that his right index finger was less curled, and he used his whole hand when grasping objects. The mother had some concerns because his speech intelligibility decreased when he wore the cast and because he appeared generally clumsier.

During the 2nd week, the child experienced no irritation or soreness from the cast. The mother noticed ongoing improvements in the right index finger and hand during unilateral and bilateral activities. The participant’s speech had improved, but he remained clumsier than normal. The mother’s greatest concerns were her son displaying fatigue and some frustration. The participant slept more than normal during the 2 weeks and always appeared tired. However, the mother thought her child’s participation in the study was valuable.

When the GCRC nurse reinterviewed the mother 3 months after intervention, the mother stated that she was pleased with constraint therapy and thought it was a worthwhile investment. The father was pleased that improvements had been maintained. In the 1st month after the study, the parents noticed minimal changes in their child’s arm use. After 3 months, they reported “dramatic improvements,” with the participant voluntarily using his affected extremity to dress himself and during play. The family and speech pathologist noted that his speech intelligibility improved to the point where individual speech therapy sessions were discontinued.

**Changes in WHO ICF Levels of Body Structure and Function**

**Melbourne Assessment of Unilateral Upper Limb Function.** During the baseline phase, the participant’s mean score was 98.0 (80.3%) of a possible 122 points (Figure 3). After intervention, he demonstrated robust changes (Figure 3, Post 1); his mean score was 108.8 (89.1%). Three months after intervention (Figure 3, Post 2), his score decreased slightly to 106.3 (87.1%) but remained above his baseline phase measures. Specific changes on the Melbourne
Assessment were in items requiring him to bring his hand to his head.

**Grip Strength.** The participant increased grip strength in both his right hand with spasticity and his left hand during the course of this study. During the baseline phase of the study, the participant had a mean score of 0.3 lb of grip with his right hemiplegic hand and 5.3 lb with his left (Figure 4). Immediately after intervention (Figure 4, Post 1), the participant increased the mean grip strength to 0.8 lb in his right hemiplegic hand and 5.7 lb in his left hand. The greatest increase was recorded 3 months after intervention (Figure 4, Post 2); the mean increase in his right hemiplegic hand was 4.2 lb and in his left hand was 9.2 lb (Figure 4). Interestingly, both hands improved in grip strength 3 months after intervention, possibly because of the reported increased hand use with both hands in daily routines.

**Pinch Strength.** During the baseline phase of this study, the participant had a mean lateral pinch strength of 0.0 lb for both his right hemiplegic and left hands. Immediately after intervention, the participant’s pinch increased slightly to an average of 0.06 lb in his left nonhemiplegic hand; his right hemiplegic hand score remained at 0.0 lb. Three months after intervention, the participant continued to have a mean score of 0.0 lb in his right hemiplegic hand and 0.56 lb in his left hand.

**Discussion**

This study documented changes using the WHO ICF framework after 2 weeks of CIMT with a 3-year-old child with right hemiplegia. It found changes in the activities and participation level in parent-identified occupation goals and performance of self-care skills and at the Body Structures and Functions level in quality of upper-extremity movement and grip strength.

The most prominent findings of this study were changes in Activities and Participation, which were observed immediately after intervention and continued to increase at the 3-month follow-up. Several studies have documented increased functional use of the arm and hand after CIMT (Charles, Wolf, Schneider, & Gordon, 2006; Crocker, MacKay-Lyons, & McDonnell, 1997; Eliasson et al., 2005; Naylor & Bower, 2005; Taub et al., 2004); however, we organized our protocol to address multilevel ICF changes. Changes at the Body Structure and Function level were documented with the Melbourne Assessment and grip strength. Our results were consistent with the findings of Wolf et al. (2006), who reported that greater increases in grip strength are observed several months after intervention; however, another study with children reported no significant changes in grip strength (Charles et al., 2006).

By measuring changes at the different ICF levels in this participant, we were able to demonstrate changes in underlying mechanisms that appear to be associated with changes in actual hand and upper-extremity changes as well as improved performance in self-care activities and participation. Additional studies measuring changes at all ICF levels are needed to further document associations between body and structure changes and changes in activities and participation for this population of children.

**Limitations and Future Directions for Research**

This study was limited by the single-subject design and descriptive statistics inherent in a case study. The Melbourne Assessment and grip and pinch were not developed for, or normed on, children under 5 years old. However, because this specific child was compliant, these measures provided valuable information relative to his function pre- and post-intervention with no attempt to compare his performance with that of peers his age. Lack of reliable, standardized measures for this age group was a limitation of the study. The lack of control groups makes it difficult to ascertain whether changes are caused by maturation, occupational intervention alone, or CIMT intervention. Future pediatric studies should continue to implement the ICF framework in randomized control trials that investigate changes in children receiving CIMT versus control children who are matched and stratified by different levels of hand function and receiving no or occupation-based intervention alone. By documenting child outcomes at all ICF levels over time
with attention to differences because of age or levels of disability and types, intensity, and duration of intervention, practitioners may better predict which children respond best to CIMT.

Immediate inability to tolerate constraint has been documented (Crocker et al., 1997), resulting in discontinuation of CIMT with a child. We chose a 2-week CIMT model to accommodate future families from rural areas in our state who were interested in short-term intensive therapy model compatible with school breaks and vacations. Our study documented good tolerance of CIMT initially with some frustration and fatigue noted near the end of the CIMT protocol. At this point, CIMT was immediately adjusted to accommodate the child’s fatigue, which parents reported as more a “mental fatigue” than a physical fatigue from his intense concentration on hand control during CIMT sessions. These findings emphasize the importance of careful monitoring for behavior changes and attention to child-friendly CIMT protocols and alternate forms of restraints that may be used (Eliasson et al., 2005; Gordon et al., 2005; Naylor & Bower, 2005).

Phone calls from the GCRC nurse to the family documented functional changes and family satisfaction at the 3-month follow-up. One unexpected change was increased speech intelligibility after CIMT. Glover, Mateer, Yoell, and Speed (2002) reported increases in spoken language beginning near the onset of the CIMT protocol, but this phenomenon remains poorly understood. Cortical reorganization changes on functional magnetic resonance imaging have been reported in adults after CIMT intervention (Mark & Taub, 2002). Studies to examine cortical reorganization in child participants would be helpful to explore links between improvement in motor function and language in children receiving CIMT.

In conclusion, this study explored CIMT in a young child with right hemiplegic cerebral palsy. It documented ICF increases in parent-identified occupational goals, quality of upper-extremity movement, performance of self-care skills, and grip strength and pinch strength. The documented increases in the child’s level of functioning affected his activity and participation in play and self-care. The results of this study are useful for both future research and practice. ▲

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References


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