OBJECTIVE. We investigated the feasibility and effectiveness of group-based constraint-induced movement therapy (CIMT) for children with hemiplegic cerebral palsy in a clinical setting.

METHOD. Seven children received CIMT together under the guidance of two occupational therapy practitioners, 2.5 hr/day, 5 days/wk for 4 wk. We used the Grasping and Visual–Motor Integration subtests of the Peabody Developmental Motor Scales to assess the primary outcome and the Functional Skills and Caregiver Assistance Scales of the Pediatric Evaluation Disability Inventory to assess the secondary outcome. Children were examined at preintervention, postintervention, and 1- and 3-mo follow-up.

RESULTS. Children demonstrated significant improvement on all outcome measures after intervention (all ps < .05, effect sizes = .39–.84), and effects were maintained at 3-mo follow-up.

CONCLUSION. This preliminary study revealed that group-based CIMT for children with hemiplegic cerebral palsy may be a feasible and effective alternative to individual CIMT in clinical practice.

Cerebral palsy (CP) is a disorder of movement and posture control resulting from a nonprogressive lesion to an immature brain (Bax, 2005). It is the leading cause of childhood disability. Hemiplegia occurs in 25%–33% of children with CP, in whom upper-extremity (UE) involvement is usually more noticeable than lower-extremity involvement (Colver & Sethumadhavan, 2003). Children with hemiplegia have motor impairments, sensory impairments, or both in the affected limbs (Exner, 2005; Fedrizzi, Pagliano, & Andreucci, 2003). As a result, they have never learned to use their affected limbs effectively and then demonstrate developmental disregard or nonlearned use of their affected limbs (Deluca, Echols, Law, & Ramey, 2006; Taub, Ramey, DeLuca, & Echols, 2004).

Many intervention methods have been developed to compensate for the deficits in UE function and activity limitations of children with hemiplegia (Boyd et al., 2010; Exner, 2005; Sakzewski, Ziviani, & Boyd, 2009). Constraint-induced movement therapy (CIMT) was initially developed to treat adults with hemiplegia (Wolf, Lecraw, Barton, & Jann, 1989). In CIMT, the less affected UE is restrained while the affected UE receives intensive training of unimanual skills. Recently, CIMT was also used with children (Aarts, Jongerius, Geerdink, van Limbeek, & Geurts, 2010; Brogårdh & Sjölund, 2006; Charles, Wolf, Schneider, & Gordon, 2006; Crocker, MacKay-Lyons, & McDonnell, 1997; de Brito Brandão, Mancini, Vaz, Pereira de Melo, & Fonseca, 2010; Deluca et al., 2006; Eliasson, Sundholm, Shaw, & Wang, 2005; Sakzewski et al., 2011; Taub et al., 2004). Despite CIMT’s moderately positive effect on motor function of the affected UE and disability in clients with hemiplegic CP, concerns have been raised regarding its appropriateness in the pediatric population.
population (Gilmore, Ziviani, Sakzewski, Shields, & Boyd, 2010). The high intensity of training and restriction of the less affected hand can result in frustration and irritability for children.

Another concern is that CIMT is labor intensive; it is usually carried out one-on-one with a therapist in a series of 2- to 6-hr training sessions (de Brito Brandão et al., 2010; Deluca et al., 2006; Eliasson et al., 2005; Taub et al., 2004). Most facilities do not have enough therapists to deliver such time-consuming treatment (Page, Levine, Sisto, Bond, & Johnston, 2002). In addition, insurance payment systems may not adequately reimburse for such intensive training. For example, in Taiwan insurers reimburse 50 min of an intervention session; longer sessions result in no additional payment. Therefore, the original CIMT delivery model requires modification before it can gain acceptance in clinical practice.

The CIMT group approach may be more practical than individual therapy given its potential to reduce total staffing hours needed for treatment implementation (Leung, Ng, & Fong, 2009). Because few studies have applied pediatric group-based CIMT in clinical practice, we aimed to investigate the feasibility and effectiveness of delivering group-based CIMT to children with hemiplegic CP in a clinical setting.

Method

Research Design

We conducted a quasi-experimental, one-group pre-intervention–postintervention and follow-up trial. The Chang Gung Memorial Hospital’s Institutional Research Ethics Committee approved this study. Informed consent was obtained from the participants and their parents.

Participants

Participants were recruited from the pediatric occupational therapy service in a tertiary hospital in southern Taiwan. The inclusion criteria were diagnosis of hemiplegic CP; between ages 2 and 14 yr; and Manual Ability Classification System (Eliasson et al., 2006) scores of I, II, or III. We excluded children who had severe paralysis in the affected UE, a visual problem that would interfere with the intervention or testing, orthopedic surgery, or botulinum toxin injection in the affected UE during the past 6 mo.

Instruments

Peabody Developmental Motor Scales–Second Edition. We used two subscales of the Peabody Developmental Motor Scales—Second Edition (PDMS–2; Folio & Fewell, 2000)—Grasping (PDMS–G) and Visual–Motor Integration (PDMS–V)—to examine the fine motor function of the affected UE as the primary outcome. The two subscales consist of 98 items, and every item was rated on a 3-point scale: 0 = unable or unwilling to do the motion; 1 = able to do the motion but not reach the standard; and 2 = the motion reaches the standard. No Chinese version of the PDMS–2 was available. Using the U.S. version, Wang, Liao, and Hsieh (2006) found that the composite scores of the PDMS–2 had good test–retest reliability (intraclass correlation coefficients [ICCs] = 0.88–1.00), and responsiveness coefficients ranged from 1.7 to 2.2 when tested with Taiwanese children with CP. Some participants in our study were older than 71 mo, which is the upper limit suitable age for testing children with the PDMS–2. Because the fine motor skills of the participants’ affected UEs were below those expected of a 71-mo-old child, we chose to use the PDMS–2 as one of the evaluation tools in this study. Because the norm references for Taiwanese healthy children are not yet obtainable, we used the raw scores for data analysis.

Pediatric Evaluation of Disability Inventory. Participants’ functioning in daily living activities was assessed with the Pediatric Evaluation of Disability Inventory (PEDI; Haley, Coster, Ludlow, Haltiwanger, & Andrellos, 1992) as the secondary outcome. The PEDI consists of a semi-structured interview with parents to assess a child’s functional skills and need for caregiver assistance in performing self-care, mobility, and social function tasks. The Functional Skills Scale measures the child’s ability to perform specific functional skills. The child receives a score of either 1 (has ability) or 0 (has not yet demonstrated ability/unable) on each item. The Caregiver Assistance Scale measures the caregiver’s typical amount of assistance provided to complete basic functional activities (scoring; 5 = independent; 4 = supervision; 3 = minimal assistance; 2 = moderate assistance; 1 = maximal assistance; 0 = total assistance). In our study, we assessed only self-care domains.

Although the PEDI was designed primarily for assessing functional performance in children 6 mo–7.5 yr old, it has also frequently been used with children with CP who are >7.5 yr old but have functional ability below that expected of typically developing 7.5-yr-old children (Ödman & Öberg, 2006; Ohata et al., 2008). The PEDI provides scaled scores, which are obtained by transforming the logit estimates for the entire normative sample to a 0–100 distribution to represent the functional performance of children without adjustment for age; the higher the score is, the better the performance (Haley et al., 1992). Therefore, we used scaled scores for
further analysis. The PEDI has high internal consistency (Cronbach’s α = .90–.99) and excellent test–retest reliability (ICCs = .982–.998) when tested with Taiwanese children with CP (Chen, Hsieh, Sheu, Hu, & Tseng, 2009).

**Intervention**

This study was conducted during weekdays over 4 consecutive wk during the summer recess. We recruited 8 children with hemiplegia to receive CIMT as a group. Each participant wore a thermoplastic short UE splint on the less affected UE during the intervention session. The group intervention program was delivered for 2.5 hr daily, 5 days/wk for 4 wk. All children were treated together during the whole treatment session under the guidance of an occupational therapist and an occupational therapy assistant. The occupational therapist designed the program, monitored participants’ performance, and modified activities for participants as required. The occupational therapy assistant took the major role of implementing the training program under the occupational therapist’s supervision.

Each session started with stretching and weight-bearing exercise of the affected UE for 15 min, followed by hand function activities (40 min), eating and drinking activities (40 min), and games (55 min). A 3–5 min break took place between each intervention component. The hand function activity training focused on the more affected UE and followed the principles of shaping and repetitive task practice. The eating and drinking activity training was designed as a teatime activity. Using their affected UE, participants were asked to put napkins on the table; cooperate to place the cups, dishes, spoons, and forks on the napkins; and then practice skills for drinking and eating. For the eating and drinking activity training, participants used different utensils in accordance with their different levels of affected hand function. Finally, participants were required to clean the table together.

During the last 55 min of the session, children were divided into two groups by age (with age 6 as the cutpoint) to play games. The occupational therapist led the younger group, and the occupational therapy assistant led the older group. The games (i.e., ball games, card games, board games, block games, puzzles) were designed to be either cooperative or competitive in nature to promote participants’ motivation.

Before intervention, both therapists discussed and set each participant’s treatment goal on the basis of the baseline evaluation results. The hand function training program was designed according to each participant’s specific problems along with personal factors such as age, cognitive level, and affected side. No home program instruction was offered to parents; we instead urged parents to encourage their child to wear the splint at home. All participants returned to their previous individual conventional occupational therapy after completing the 4-wk group CIMT.

**Data Collection**

All participants were assessed on four occasions—preintervention, postintervention, at 1-mo follow-up, and at 3-mo follow-up—by the occupational therapist, who designed the intervention program. Parents were interviewed at the same time points to assess on a 5-point scale how much of the time their child used the affected UE at home (scoring: 0 = never; 1 = less than 25% of the time; 2 = 26%–50% of the time; 3 = 51%–75% of the time; or 4 = more than 75% of the time). Six activities were observed: eating, grooming, bathing, dressing upper body, dressing lower body, and toileting. Sum scores were obtained for a maximum score of 24. The parents’ perspectives were also obtained postintervention. The two practitioners also provided feedback to the physiatrist, who supervised the project, after the intervention to give their subjective view of the intervention model.

**Data Analysis**

Descriptive statistics were used to describe participant demographics. We used Wilcoxon signed-ranks tests to analyze preintervention and postintervention data to reveal any significant change in outcome measures after intervention. To determine whether possible effects remained constant for 3 mo, we also used Wilcoxon signed-ranks tests to compare the results between postintervention and 1-mo and 3-mo follow-up. We also calculated effect size to index the magnitude of intervention effect. Hedge’s g was used because of the small sample size. Hedge’s gs of .2 are considered small; .5, medium; and .8, large (Cohen, 1988). We conducted all statistical analyses using SPSS 13.0 (SPSS Inc., Chicago). The significance level was set at .05 for all tests.

**Results**

Eight participants (4 boys, 4 girls; mean age = 6.54 yr, standard deviation = 3.13) were recruited to receive CIMT together as one group. One boy withdrew in the 1st wk because of transportation problems; 7 participants completed all treatment and measurement sessions. The baseline data of the study participants are shown in Table 1.

Table 2 and Figures 1 and 2 show the improvement in fine motor skills and daily living activities function
Practitioners’ and Parents’ Opinions

The two occupational therapists cooperated to provide treatment. They approved the model of two practitioners leading one group. They found that children were more willing to receive CIMT in a group than in individual therapy. Although the practitioners conducted the 7-child group successfully, they suggested a participant:practitioner ratio of 2–3:1 as optimal. In other words, they recommended that two practitioners guide a group of 4–6 children. They further suggested recruiting participants for a group who had similar functional limitations and age range to make it easier to design and conduct the program. They also recommended that each treatment session last no more than 2 hr and incorporate short breaks throughout the entire training session because children may lose their attention or motivation during longer periods.

All parents appreciated the effect of the group-based CIMT. They observed improvement in their child’s function and frequency of use of the affected UE. Most parents reported that they did not encourage their child to wear the UE splint at home.

Discussion

This pilot study supports the feasibility of applying group-based CIMT to children with hemiplegic CP in a clinical setting. In addition, children receiving group-based CIMT had significant gains in manual performance of the affected UE and self-care function postintervention. The spontaneous use of the affected UE also increased.

According to previous research, restraint and intensive, repetitive training may affect participants’ motivation to use CIMT (Charles et al., 2006; Gilmore et al., 2010), and the high labor demand may prohibit use of CIMT in the clinical setting (Page et al., 2002). Therefore, increasing participants’ motivation and decreasing the CIMT’s manpower demand are important for successful implementation of CIMT.

Group intervention may fulfill these requirements. Small-group intervention has already been applied in

Table 1. Study Participants’ Data

<table>
<thead>
<tr>
<th>Child</th>
<th>Affected Side</th>
<th>Gender</th>
<th>Age, Yr:Mo</th>
<th>MACS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Right</td>
<td>Male</td>
<td>5:6</td>
<td>I</td>
</tr>
<tr>
<td>2</td>
<td>Right</td>
<td>Female</td>
<td>6:1</td>
<td>II</td>
</tr>
<tr>
<td>3</td>
<td>Right</td>
<td>Male</td>
<td>10:0</td>
<td>III</td>
</tr>
<tr>
<td>4</td>
<td>Left</td>
<td>Male</td>
<td>6:5</td>
<td>III</td>
</tr>
<tr>
<td>5</td>
<td>Left</td>
<td>Female</td>
<td>2:4</td>
<td>III</td>
</tr>
<tr>
<td>6</td>
<td>Left</td>
<td>Female</td>
<td>4:2</td>
<td>II</td>
</tr>
<tr>
<td>7</td>
<td>Left</td>
<td>Female</td>
<td>11:3</td>
<td>III</td>
</tr>
</tbody>
</table>

Note. MACS = Manual Ability Classification System; I = the child can independently manipulate different objects that require speed and accuracy without limitations; II = the child can manipulate most of the objects and has independent performance but may show reduction in the speed or quality of movement; III = the child has diminished ability to manipulate objects and may need assistance to prepare or modify the activity to be performed.

Table 2. Outcome Measures Pre- and Postintervention (N = 7)

<table>
<thead>
<tr>
<th>Outcome Measure</th>
<th>Preintervention, M (SD)</th>
<th>Postintervention, M (SD)</th>
<th>Z (p)</th>
<th>Hedge’s g</th>
<th>1-Mo Follow-Up, M (SD)</th>
<th>3-Mo Follow-Up, M (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PDMS–G (range = 0–52)</td>
<td>37.14 (7.88)</td>
<td>42.14 (5.98)</td>
<td>-2.41 (.016)</td>
<td>0.67</td>
<td>43.29 (5.91)</td>
<td>42.86 (6.09)</td>
</tr>
<tr>
<td>PDMS–V (range = 0–114)</td>
<td>83.57 (20.78)</td>
<td>102.57 (21.54)</td>
<td>-2.38 (.018)</td>
<td>0.84</td>
<td>106.43 (20.93)</td>
<td>105.86 (22.19)</td>
</tr>
<tr>
<td>PEDI–FS (range = 0–100)</td>
<td>50.01 (7.92)</td>
<td>53.17 (7.38)</td>
<td>-2.37 (.018)</td>
<td>0.39</td>
<td>54.89 (7.18)</td>
<td>55.51 (7.56)</td>
</tr>
<tr>
<td>PEDI–CAS (range = 0–100)</td>
<td>50.93 (11.55)</td>
<td>60.01 (10.70)</td>
<td>-2.37 (.018)</td>
<td>0.76</td>
<td>60.66 (8.85)</td>
<td>58.64 (8.69)</td>
</tr>
<tr>
<td>Use scores (range = 0–24)</td>
<td>5.43 (5.09)</td>
<td>12.00 (5.45)</td>
<td>-2.37 (.018)</td>
<td>1.13</td>
<td>11.43 (4.83)</td>
<td>10.86 (4.60)</td>
</tr>
</tbody>
</table>

general pediatric rehabilitation for UE functional training. The group therapy setting allows participants to observe and learn from one another, as well as to support each other and collaborate when confronting difficulties. In addition, children are more willing to engage in repetitive actions while playing games in a group than when in an individual therapy session (Exner, 2005). Moreover, in some games, more players create greater benefit than just one child facing the therapist. Therefore, the group therapy appeared to help children overcome the difficulties and frustration of performing CIMT.

Page et al. (2002) reported that most therapists may find it difficult to develop an intensive protocol that is both engaging and challenging. Because few experienced therapists may be available in a clinic setting, we arranged for an experienced therapist and a therapist assistant to lead one group. The experienced therapist designed the program, monitored participants’ daily performance, and modified the tasks for the participants as required, and the occupational therapy assistant primarily implemented the training program. Both therapists supported this model as valid and workable.

Previous group-model studies for participants who had either a stroke or CP have used the small-group format (Aarts et al., 2010; Brogårdh & Sjölund, 2006; Charles et al., 2006; Leung et al., 2009), and the participant–therapist ratio ranged from 2:1–4:1; thus, we developed this “8-child group led by two therapists” model. After the intervention, the two therapists recommended a “4- to 6-child group led by two therapists” model (participant–therapist ratio of 2:1–3:1) as more optimal. The group training program should cohere with the personal factors and needs of each participant; therefore, we recommend that participants with similar functional limitations and age range be recruited for a specific group.

The duration of each CIMT session varies widely among studies, ranging from 2 to 6 hr per session (Aarts et al., 2010; Charles et al., 2006; de Brito Brandão et al., 2010; Deluca et al., 2006; Eliasson et al., 2005; Sakzewski et al., 2011; Taub et al., 2004). Because our occupational therapy room was open from 8:30 a.m. to 12:00 p.m. and then again from 1:30 p.m. to 5:00 p.m., we thought training sessions would have to be <3 hr to be practical. Considering children’s attention and motivation limits, we suggested limiting each session to 2 hr with frequent short breaks.

Figure 1. Trend in Peabody Developmental Motor Scales–Second Edition (PDMS–2) scores at preintervention, postintervention, and 1- and 3-mo follow-up.


Figure 2. Trend in Pediatric Evaluation of Disability Inventory (PEDI) scores and spontaneous use of the affected upper extremity at preintervention, postintervention, and 1- and 3-mo follow-up.

Note. PEDI–FS = Functional Skills Scale of the PEDI; PEDI–CAS = Caregiver Assistance Scale of the PEDI.
In Taiwan, the general principles of insurance payment are based on the number of children being treated and the duration of each session. Although payment increases with treatment duration, payment will usually not be extended beyond 1 hr. This payment principle discourages treatment sessions of longer duration. In our group CIMT, therapists could treat similar numbers of children as in conventional individual therapy and therefore obtain similar payment for 2- to 3-hr sessions. This intervention format could promote the greater acceptance of CIMT in clinical practice.

The participants showed significant improvement in manual performance of the affected UE as well as great improvement in self-care functioning. Parents also commonly reported that the children used the affected hand more postintervention. These results are compatible with those of individual CIMT programs (Crocker et al., 1997; de Brito Brandão et al., 2010; Deluca et al., 2006; Taub et al., 2004) and illustrate that group CIMT may be a practical and cost-efficient method.

At the 3-mo follow-up, the participants showed a small but nonsignificant decline in function and use of the affected UE. This finding was in line with those of previous CIMT studies (Aarts et al., 2010; Charles et al., 2006; Taub et al., 2004). We were not able to determine whether maintaining the intervention effect depended on the total training dosage. In previous studies, the total training dosage of each CIMT course ranged from 54 to 120 hr (Aarts et al., 2010; Charles et al., 2006; de Brito Brandão et al., 2010; Eliasson et al., 2005; Sakzewski et al., 2011; Taub et al., 2004). The total training dosage depends on the frequency and duration of the intervention; the optimal training dosage has yet to be determined. According to our results, the total training dosage of 60 hr seemed effective. If the premise is an intervention time of 2 hr/session, a 6-wk intervention period to deliver intensive training during a school recess (i.e., summer or winter) is suggested. With regard to the retention of training effects, we could likely implement CIMT 2 times/yr, each for 6 wk, to coincide with the winter and summer recesses.

Limitations

The weakness of our study was that it had a small number of participants and was not a randomized controlled trial. In addition, the assessments were not performed by a blinded therapist. Future randomized controlled trials with participants of a wide age range and with a variety of manual abilities, and with assessors blinded to the type of intervention, would be useful to determine the effectiveness of this intervention protocol. The outcome measures in our studies were also limited. Because some participants were older than the suitable age range for the PDMS–2 and PEDI and the norm references for Taiwanese healthy children are not obtainable, we used the raw scores, rather than age-specific norm-referenced scores, for data analysis. The improvement might be the result of maturation, especially for young children. Moreover, we assessed only the manual function of the affected UE and participants’ performance of self-care. Assessing other health-related domains, such as participation, and including participants’ perspectives may broaden occupational therapists’ understanding of the overall effect of group-based CIMT.

Implications for Occupational Therapy Practice

The results of this study have the following implications for occupational therapy practice:

- Group-based CIMT is a feasible and effective intervention for children with hemiplegic CP.
- Group-based CIMT can increase the motivation of children with CP to engage in intensive, repetitive training and decrease CIMT’s demands on therapists.
- Group-based CIMT had similar effects as individual CIMT programs: It can improve manual performance, use frequency of the affected UE, and self-care functioning.

Conclusion

This preliminary study demonstrated that group-based CIMT can be implemented in clinical practice to improve both manual performance and frequency of functional use of the affected UE in self-care activities in children with hemiplegic CP. The results will provide insights for designing a large-scale, randomized trial to clarify the efficacy of group-based CIMT. In future studies, we recommend the use of two therapists to lead a 4- to 6-child group in training delivered 2 hr/day, 5 days/wk for 6 wk, during the winter and summer school recesses. ▲

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References


