Effects of Modified Constraint-induced Movement Therapy on Hand Dexterity, Grip Strength and Activities of Daily Living of Children with Cerebral Palsy: a Randomized Control Trial

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Abstract. [Purpose] This study investigated hand function and activities of daily living (ADL) changes in children with hemiplegic cerebral palsy (CP) using modified constraint induced movement therapy (mCIMT). [Subjects] Twenty children with CP were randomly allocated into mCIMT (n = 10) and control (CON) (n = 10) groups. [Methods] Two expert physical therapists provided the mCIMT and CON groups with traditional rehabilitation therapy in 30-minute sessions, semi-weekly, for 10 weeks. The mCIMT training was provided only to mCIMT group semi-weekly for 10 weeks at 60 minutes per session. The CON group received traditional therapy only. Before and after the 10 weeks of intervention, hand function and ADL evaluations were performed, and the obtained data were analyzed. [Results] The mCIMT and CON groups showed significant differences in hand dexterity and grip strength on the affected side and ADL self-care subtest scores. [Conclusion] The results are not generalizable to all children with CP because of the small number of subjects. Detailed and diverse investigations should be performed by considering the number and characteristics of subjects and the limitations influencing the mCIMT training period. Key words: Cerebral palsy, Modified constraint-induced movement therapy, Hand function

INTRODUCTION

There are various types of cerebral palsy (CP) including spastic, athetoid, and ataxic CP. Among these the spastic hemiplegic type accounts for 30%. Patients with spastic hemiplegic CP show characteristic symptoms of spasticity and muscle weakness, or paralysis in the affected arm, leg, or trunk, which results in movement disorders often affecting one side of the body more severely1, 2). Most patients with hemiplegic CP use their non-affected arm for their activities of daily living (ADL). The time that they favor using the non-affected arm consequently extends the time span of functional recovery of the affected side3). The patient’s preference for using the unaffected arm and their avoidance of the affected arm becomes learned, and this phenomenon is called “learned non-use syndrome.” Constraint-induced movement therapy (CIMT) has been successfully implemented for patients with stroke and incomplete spinal cord injury, and is also used to reverse the learned non-use syndrome4). However, because CIMT involves restraining the unaffected arm using a splint or other devices to force the patient to use their affected arm and requires intensive training, it is difficult to conduct with pediatric patients5). To reduce children’s reluctance to participate in CIMT and overcome the method’s application limits, the modified CIMT (mCIMT) was developed. The mCIMT reduces the hours of restraining the non-affected arm to 5 hours a day and includes 1 hour of intensive training for the affected arm every 10 weeks6). Reports suggest that mCIMT is more effective at improving arm motor function of patients with hemiplegic cerebral palsy than the traditional CIMT6–8). However, little research has been done on mCIMT for children. Therefore, the present study was conducted to determine what influence mCIMT has on hand function and ADL of patients with hemiplegic CP.

SUBJECTS AND METHODS

This study included 24 children with hemiplegic CP and was performed at S Hospital in Korea in 2011. The subject selection criteria are as follows: no mCIMT-related treatment in the previous 2 years, voluntary movement not limited when the non-affected side is restrained, no difficulties in performing passive range of motion (ROM) exercises and some active ROM (voluntary wrist extension of 10° or more, and voluntary each finger extension of 10° or more) on the affected side, and no cognitive deficits (children who were able to understand the instructions of therapist). Two groups...
(mCIMT training [mCIMT] and control [CON]) were randomized using a table of random sampling numbers. The groups were segregated from each other for a single-blind analysis: one group received treatment in the morning, and the other group received treatment in the afternoon. The patients were asked not to discuss their protocol with members of the other group. The subjects in the 2 groups received traditional rehabilitation therapy in 30-minute sessions, semi-weekly. The patients in the mCIMT training group also received mCIMT sessions in 60-minute sessions, for 10 weeks. After the mCIMT intervention, a posttest was performed, and the data obtained were analyzed. Ten children from each group participated in the posttest; their demographic characteristics are shown in Table 1.

During the 60-minute mCIMT, the non-affected arm was restrained with a string and a splint made of a light material. The arm position during restraint was as follows: 90° elbow flexion, 20° wrist extension, and 20° finger joint flexion9).

The mCIMT training tasks consisted of 13 activities including transferring a small object with a spoon, performing button closures, manipulating clothespins, ring tossing, card games, keyboard strokes, grab-bars-meet-the-balloon, building a stuffed animal, playing with water pistols, building with blocks, and playing with toys with the affected arm and hand. These exercises were designed so that the patients grasped, seized, held, and handled various objects of different sizes and weights. The training was carried out according to a specific protocol10).

The box and block test (BBT) is a clinical evaluation tool for measuring arm dexterity and hand manipulation ability that is widely used to assess ADL. The test measures the number of wood blocks a patient is able to grasp and transport to another spot with the affected hand. The inter-reliability among testers has been reported as $r = 0.93$–1.0011).

A hand dynamometer was used to measure grip strength, and the posture during the measurement was as follows: shoulder in a neutral position, 90° elbow flexion, forearm in a neutral position, 0°–30° wrist extension, and 0°–15° ulnar deviation. The average of 3 independent measures of one hand were recorded. A 20-second interval is required between each measurement to minimize the aftereffects of measurement2).

The Wee-functional independence measure (WeeFIM) was used to evaluate the ADL independence level of the children with disability. The basic ADL evaluation comprises 18 items. There are 13 motor subtest items that include 6 items of self-care, 2 items of bowel and bladder control, 3 items of transfer, and 2 items of locomotion. The cognitive subtest consists of 5 items; 2 items of communication and 3 items of social cognition. The WeeFIM score ranges from 18 (maximally dependent level) to 126 (full independent level). Each item is rated on a 7-point scale15).

SPSS ver. 12.0 was used to calculate the means and standard deviations. Descriptive statistics were used to analyze the general subject characteristics. The differences in hand function and ADL scores between the 2 groups were investigated using the independent t test. For all the data, significance was accepted at values of $p<0.05$.

### RESULTS

The hand function, grip strength and ADL scores before and after the mCIMT are shown in Table 2. The mCIMT and CON groups showed significant differences in the following measures: BBT, grip strength of the affected side and WeeFIM (self-care subtest score) ($p<0.05$).

### DISCUSSION

This research investigated the efficacy of mCIMT by measuring hand dexterity, grip strength, and ADL of children with hemiplegic CP. CIMT has been shown to improve upper extremity function and ADL, but most children are reluctant to submit to CIMT because it restrains body movement and requires sustained concentration. Therefore, children can lose interest or become passive during CIMT, making it difficult for therapists to perform CIMT with children. It has become widely accepted that unconditional restraint of the non-affected side is less effective than flexible application of restraining therapy in various environments5). Therefore, mCIMT uses a different restraint method in shorter session times over 10 weeks, and it is recognized to be effective4).

The results described here demonstrate that compared with the CON group, the children with hemiplegic CP who received mCIMT showed improvements in dexterity and grip strength of the affected side. According to Rostami et al., 14 children with spastic hemiplegic CP receiving mCIMT for 10 sessions showed significant improvement in post-test measures of Bruininks-Oseretsky test of motor proficiency3). Their result indicates that mCIMT is effective at improving the upper limb function of children with spastic hemiplegic CP. According to Aarts et al., 52 children with unilateral spastic cerebral palsy received 8 weeks of mCIMT but failed to show significant improvements in spastic motion or strength of their affected arm5). Their lack of a positive result may be because the mCIMT training period was too short. In the present work, the mCIMT training was 10 weeks long, and improvements in dexterity and grip strength were observed in the affected hand.

According to a report by Sung et al., 31 children who received CIMT training showed significantly improved hand function and ability to conduct ADL. Our results corroborate their research in that our pediatric patients who received the mCIMT showed improvements in WeeFIM motor subtotal score (self-care subtest score) and WeeFIM total score compared with the CON group. Therefore, like
CIMT, mCIMT training improves patients’ dexterity and grip strength on their affected side. In addition, we expect that continuous training would contribute to improved WeeFIM scores. Our results reflect that the 13 kinds of mCIMT training activities (small object transfer with spoon, replacing buttons, etc.) improved self-care skills.

Our results also indicate that mCIMT should be considered for various clinical settings, and to that end, it would be useful to develop other protocols that increase children’s interest in mCIMT training activities. Additional research on long-term treatment for children with hemiplegic cerebral palsy should be carried out to verify its efficacy and long-term effects.

REFERENCE

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Table 2. Comparison of hand dexterity, grip strength and ADL of each group

<table>
<thead>
<tr>
<th></th>
<th>mCIMT</th>
<th>CON</th>
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<tbody>
<tr>
<td>Pre-test</td>
<td>Post-test</td>
<td>Pre-test</td>
</tr>
<tr>
<td>BBT (number) *</td>
<td>15.7 ± 3.5</td>
<td>18.6 ± 3.7</td>
</tr>
<tr>
<td>Grip (kg) *</td>
<td>9.0 ± 3.3</td>
<td>10.5 ± 3.6</td>
</tr>
<tr>
<td>WeeFIM-motor (score) *</td>
<td>48.5 ± 11.0</td>
<td>51.0 ± 10.3</td>
</tr>
<tr>
<td>Self-care (score) *</td>
<td>19.4 ± 4.1</td>
<td>21.7 ± 3.6</td>
</tr>
<tr>
<td>Sphincter control (score)</td>
<td>9.9 ± 3.9</td>
<td>10.0 ± 3.8</td>
</tr>
<tr>
<td>Mobility (score)</td>
<td>11.5 ± 3.9</td>
<td>11.6 ± 3.8</td>
</tr>
<tr>
<td>Locomotion (score)</td>
<td>7.7 ± 2.4</td>
<td>7.8 ± 2.4</td>
</tr>
<tr>
<td>WeeFIM-cognition (score)</td>
<td>23.0 ± 4.8</td>
<td>23.9 ± 4.2</td>
</tr>
<tr>
<td>WeeFIM total (score) *</td>
<td>71.5 ± 11.2</td>
<td>74.9 ± 10.4</td>
</tr>
</tbody>
</table>

Note. All variables are mean ± standard division (SD). *p<0.05. mCIMT: modified constraint-induced movement therapy group. CON: control group. BBT: box and block test. Grip: grip strength. WeeFIM: Wee functional independence measure.