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Original Research

The Effect of the Modified Constraint-Induced Movement Therapy on the Upper Extremity Functions of Obstetric Brachial Plexus Palsy Patients

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Abstract

Objectives: Functional limitation of the upper extremity (UE) in obstetrical brachial plexus paralysis (OBPP) restricts a child's participation in daily living and social activities. In treatment, the participation of UE in rehabilitation is important. Constraint-induced movement therapy (CIMT) is a promising rehabilitation approach that is used to improve the UE functions of patients with neurological dysfunctions.

Methods: This single-blinded randomized controlled clinical trial includes 30 pediatric patients diagnosed with chronic OBPP aged between 2 and 12 years. The patients were divided into two groups as a modified CIMT group and a control group. Patients in both groups underwent classical rehabilitation treatment 4 times a week for 8 weeks. Range of motion (ROM), stretching, strengthening, and proprioceptive exercises were given to both control and CIMT group. The patients in the CIMT group had to wear constraining arm slings 2 h per day and 4 days a week for 8 weeks. The patients were evaluated both before and after treatment using the Mallet classification system and the Melbourne unilateral upper limb assessment-2 (The MA2) scale.

Results: In both groups, the Mallet and MA2 scores significantly increased after the treatment process. However, the percentage of improvement was higher for the CIMT group.

Conclusion: Modified CIMT improves the joint ROM and the functional use of the extremity among OBPP-diagnosed children. This improvement is greater in the CIMT group compared to the improvement in the control group. Implementation of CIMT in a routine rehabilitation process may be helpful.

Keywords: Brachial plexus, constraint-induced movement therapy, rehabilitation

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Obstetric brachial plexus palsy (OBPP) is the partial or total paralysis of an upper extremity (UE) due to injury to the brachial plexus (in the form of stretching or rupture) during birth.[1,2] It is relatively rare hopefully, and has an incidence between 0.04 and 0.4% of live births.[3] The risk factor for OBPP is the stretching of the brachial plexus due to shoulder dystocia, prolonged labor, delivery with instruments, overweight of the mother, and a previous history of OBPP of siblings.[3] In a study by Angin et al., signs of brachial plexus injury were observed in 39% of newborn babies with shoulder dystocia.[4] The reported incidence rates of permanent sequels ranges from 10–20% to 5–50%.

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[1] Paralysis of C5-6 roots (Erb-Duchenne paralysis) is the most common form (50–60%).[3] The elbow usually in the extended position, the forearm in pronation, and the wrist in extension is a common position in Erb-Duchenne paralysis.[3] If the injury includes C7 root, the wrist is in flexion and ulnar deviation.[3] Weakness of the internal rotators and shoulder abductors leads to stiffness and fixation of the glenohumeral joint in internal rotation. Forearm pronators, wrist and finger flexors may also shorten if active motion is not present.[5] A multidisciplinary approach including physiotherapy and occupational therapy is required for the maintenance of the joint range of motion (ROM) and muscle strength.[1,6] Functional rehabilitation is essential and is the first choice in treatment.

Most children with OBPP recover without deficit or with small functional deficits, but some cannot regain adequate arm function. Motor and sensory disturbances associated with different types of brachial plexus palsy prevent the affected limb from being used in different activities. These problems force the child to use the unaffected arm in daily life and the problems of the paretic limb increase.[7,8]

In a recent series of studies, it has been suggested that constraint-induced movement therapy (CIMT) is an effective and child-friendly treatment method for improving UE function of hemiplegic children.[9] This non-invasive treatment method also supports neural plasticity in children with OBPP to learn non-use and the developmental neglect of the affected arm.[9,10] It is based on the principle of restricting the use of the unaffected extremities and forcing the use of the paretic extremity throughout the day. The foundations of this therapy were laid by Knabb and Taub between 1963 and 1981.[11] With the use of CIMT in hemiplegic patients, it has been shown that the human brain has life-long plasticity. When repetitive exercises were performed on the affected limb after injury, it was observed that the area of the involved motor cortex was reorganized, that is, the area around the damaged region assumed the respective functions for the affected limb.[12] The improved primary sensorimotor cortex regarding the affected limb following a 12-day CIMT application among children with OBPP was shown with fMRI.[12]

Peripheral plasticity evidence is present in early functional recovery after paralysis in OBPP patients.[5] Studies have shown that some neonates have neglected their arm and refused to use it, even if the muscle function is restored.[2,5] With these findings, Shepherd first thought in 1999 that the CIMT principles could be applied in OBPP patients.[2] Over time, the OBPP recovery process does not only depend on the restoration of peripheral nerve endurance, but also the plasticity of the associated spinal cord area.[1]

CIMT, described by Taub et al.[10] in 1980 is a promising rehabilitation treatment that is used to improve UE functions of the patients with neurological dysfunctions including OBPP.[1,7,10] In children with unilateral CP, there is evidence that CIMT improves bimanual performance and unimanual capacity.[13]

It is thought that the developmental neglect of the affected arm in OBPP can affect cortical representation and lead to partially permanent motor functional disorders. The literature indicates that in some cases, the babies with OBPP do not use their affected arms, even if the muscle functions are restored.[5,14] Several studies argue that the treatment of children with OBPP should be based on CIMT principles.[1,2,15-17] The purpose of this prospective randomized controlled trial is to investigate the effects of CIMT on the shoulder ROM and monitor its effects on the functions of the affected upper extremities of children which are eating with a spoon, drinking from a glass, brushing teeth, etc., that are diagnosed with chronic OBPP.

Methods

This study was approved by the ethical committee of our hospital (decision no: 240, year: 2014). The parents of all participants have given written informed consent for their children's participation in the study. This study conforms to all CONSORT guidelines and reports the required information accordingly.

Participants were selected from among the patients who applied to our physical medicine and rehabilitation clinic and were diagnosed as OBPP. There were a total of 30 patients that were diagnosed as OBPP with neurologic examination and electroneuromyographic studies by a physiatrist. Groups were formed by randomized sampling and all eligible children were informed about the study. The age of the participants ranged between 2 and 14. The inclusion criteria were as follows: Cognitive function at a level where the participant can perform the required tasks, 10-degree wrist and metacarpophalangeal joint extension, and 10-degree thumb abduction. The exclusion criteria were as follows: Having any serious congenital disorder other than OBPP; having severe visual and/or hearing impairment; being stage IV in Narakas classification; having an active disease (e.g., pneumonia); having undergone a major surgical operation on the involved extremity, nerve blockage, or botulinum toxin injection in the past 6 months.

The patient's lesions were classified according to the Narakas classification:[18] (1) Stage I: C5-6; shoulder and biceps palsy, (2) Stage II: C5-7; shoulder, biceps, and forearm extensor palsy, (3) Stage III: C5-T1; total paralysis of one arm,

and (4) Stage IV: C5-T1; the same clinical table as Stage III together with Horner's syndrome which is the combination of ptosis, myosis, and anhidrosis in a damaged sympathetic nervous system.[19]

A total of 30 patients were included in the study. The participants were then randomly divided into two groups using a random number table with 15 participants in each group. Randomisation was key concealed until the group allocation was performed. The participants in the study group (Group 1) also underwent conventional exercise and CIMT was included. The participants in the control group (Group 2) underwent conventional exercise treatment for 8 weeks.

The g$roup 1 was engaged in CIMT which was applied for 8 weeks, 4 days a week, and 2 h per day. A trained caregiver applied for the program at home. A sling was used to constrain the unaffected arm. The sling covered the patient's hand, forearm, and elbow. With the sling, the patient's finger, wrist, and elbow movements were stopped and shoulder movements were also restricted. During the 2 h in which the unaffected arm was constrained, the trained caregiver was asked to help the children perform certain tasks with the affected arm. A physiatrist and a physiotherapist trained caregiver who apply CIMT. These tasks were handed to the trained caregiver in the form of a written list, together with a calendar, to assure that CIMT was performed regularly each day. The Group 2 repetitively applied conventional exercises for 8 weeks and 4 days a week at home. The exercises applied to the Groups 1 and 2 are shown in Table 1. The scope of both exercise programs as outlined by the physiatrist and a physiotherapist experienced in pediatric rehabilitation.

The patients were examined both before and after the study by a physician that was blind to the treatment method, using the Modified Mallet Classification System by Tassin and Gilbert[20] and the Melbourne Assessment-2 Unilateral UE Evaluation Kit (The MA2). The MA2 was purchased from the Occupational Therapy Department of the Royal Children's Hospital and approved for use in the study.

The MA2 test is a method that can be used to measure the function of the UE in children and to plan treatment.[1,21] It was developed by Randall et al. to assess the degree of unilateral UE disorders of children aged 2–15.[21] It is, in fact, a modified version of the MA2 scale that was developed in 1999 by the same researchers. Originally, there are 16 test items and 37 score items.[22] With removal of 2 test items and 7 score items, the MA2 consists of 14 test items, and 30 score items.

Table 1. Exercise Protocol for Group 1 and 2

Exercises for Group 1	**Exercises for Group 2**
(All exercises applied to the Group 2 were also applied to this group)	
ROM with the sling	**ROM**
• Flexion, extension, abduction, and rotation of the shoulder	• Flexion, extension, abduction, and rotation of the shoulder
• Flexion and extension of the elbow	• Flexion and extension of the elbow
• Supination of forearm	• Supination of forearm
• Extension of wrist and finger	• Extension of wrist and finger
Functional Exercises with the sling	**Stretching exercises**
• Playing with a small toy ball (throwing the ball, catching the ball from different angles)	• Internal rotators, adductor, and extensors of shoulder Flexors of elbow and wrist
• Playing with modeling clay	**Strengthening exercises**
• Playing with LEGOS (building towers or different shapes from the toy bricks)	• By throwing a ball in different directions above head position,
• Drawing with crayons	• By drawing on paper stuck on the wall or window at different heights,
• Tearing a paper towel from a roll	• By supinating bottles weighing <500g as tolerated by the child
• Holding and eating biscuits	• By theraband exercises above, across, and below the chest.
• Eating with a spoon	
• Drinking from a glass	
• Combing hair	
• Brushing teeth	
• Making bubbles using a bubble blower	
• Pulling a toy	
• Placing a hat or piece of cloth on head	
• Applying lotion to the trained caregiver	

The MA2 evaluates the quality of UE movement under four categories: Movement range, accuracy, dexterity, and fluency in children.[23-25] The 14 test items of the MA2 are every-day tasks such as to reach, grasp, release, and manipulate simple objects. The participants are video-recorded during the test. Subsequently, the videos are evaluated and scored. The preparation of the test set takes 10 min, and the actual test lasts for 20–30 min. The assessment is done in a silent place. The table and chair should be appropriate and comfortable for the child's size. The test materials consist of a reality kit, a scoring chart, and a handbook. The preparation of the test environment and the placement of the video equipment should be done according to the instructions of the author.[23-25] The acts of reaching, grasping, releasing, and manipulating simple objects are watched again. The 30 items are scored using 3, 4, or 5-point scales according to the scale criteria. Every element of the evaluated movement is categorized into four sub-scales and scored. The summation of all of the scores of the sub-scales makes up the score of the child. For this reason, in the MA2 the final score of each patient is presented as four separate scores that evaluate the four elements of each movement (Table 2).[23-26] The results are given in percentages. Higher percentages indicate a better UE function.

The Mallet classification system has been validated in brachial plexus palsy.[27,28] Modified Mallet scale evaluates five active shoulder movements, namely abduction, external rotation, hand to the neck, hand to back, and hand to mouth. The grading scale is between I (no function) and V (normal movement, symmetric with the healthy side). A total Mallet score is calculated from the scores for the abduction of the shoulder, hand to the neck, hand to back, hand to mouth, and external rotation of shoulder which adds to a maximum score of 25.[29] Angles are measured from video recordings at patient visits for the abduction of the shoulder, hand to mouth. External rotation of shoulder was usually estimated as less or more than 20 degrees.[30,31] Grading was done according to modified Mallet Scale with measurement made from video recordings. Hand to the neck and hand to back movements are classified as impossible, difficulty, and easy according to the modified Mallet scale. Abzug et al. subsequently added a sixth function (internal rotation) to assess whether, for patients who were unable to raise their hand to their navel without flexing the wrist.[32] In addition to the Modified Mallet scale, we also performed internal rotation evaluation.

Statistical Analysis

The data were analyzed using the Number Cruncher Statistical System 2007 Statistical Software (Utah, USA) package program. Shapiro–Wilk test was used to determine the normality of the distribution of the data.

Table 2. The MA2 items and scoring

	ROM	Accuracy	Dexterity	Fluency
1. Movement Range	0 1 2 3	0 1 2 3	-	0 1 2 3
2. Reaching to the sides-upwards	0 1 2 3	0 1 2 3	-	0 1 2 3
3. Grasping a pencil	-	-	0 1 2 3	-
4. Grasping for drawing	-	-	0 1 2 3 -	-
5. Releasing the pencil	0 1 2 3	0 1 2 3	0 1 2 3	-
6. Grasping a marble	-	-	0 1 2 3 4	-
7. Releasing the marble	0 1 2 3	0 1 2 3	0 1 2 3	-
8. Manipulation	-	-	0 1 2 3	0 1 2 3
9. Pointing: The green square the blue square	-	0 1 2 3 4	-	-
10.Extending from the forehead to the nape	0 1 2 3	-	-	0 1 2 3
11.Touching the buttocks with the palm of the hand	0 1 2	-	-	0 1 2 3
12.Pronation/supination	0 1 2 3 4	-	-	-
13.Touching the opposite shoulder	0 1 2 3	0 1 2 3	-	0 1 2 3
14.Raising the hand to the mouth and lowering back down	0 1 2 3	0 1 2	-	0 1 2 3
Total subscale scores				
Maximum total score	27	25	17	21
Score %	Patient's score/ 100			

Scoring of 30 items is completed using scales according to scoring criteria. Each element of the evaluated movement is scored by categorizing it into four relevant subscales. The score of each subscale is summed to determine the total score. Therefore, in MA-2, each child's final score is given as four separate scores, each measuring the quality of different elements of the movement. Results are given as a percentage. The MA2: Melbourne unilateral upper limb assessment-2 Scale.

The following methods were used to analyze the data: Descriptive statistics (mean, standard deviation, and interquartile range). Independent t-test was used to compare paired groups of normally distributed variables, paired t-test was used for pre-and post-treatment evaluations of the groups, Mann–Whitney U test was used to evaluate the percentages of change pre- and post-treatment for non-normally distributed variables, and Chi-square and Fisher exact tests were used for comparisons of qualitative data. The median value was also determined by calculating the interquartile range in which the percentage change between pre- and post-treatment in the Mallet and MA-2 scores was compared. The results were evaluated at the significance level of $p<0.05$.

Results

There were a total of 30 participants (20 females and ten males). None of the patients had a drop during the study (Fig. 1). Males were between 24 and 156 and females were between 24 and 120 months old. The average of the male patients was higher but did not reach statistical significance.

The demographic data of Groups 1 and 2 (mean age, gender distribution, and birth weight) are in Table 3. In addition to demographic data, in Table 3, information about the patient's participation in overhead sports, education level, identity of the caregiver, and the caregiver's help during the play are also given. The delivery method, affected side, preferred side, OBPP types, operation and physiotherapy history, etc., of the patients in Groups 1 and 2 are shown in Table 3.

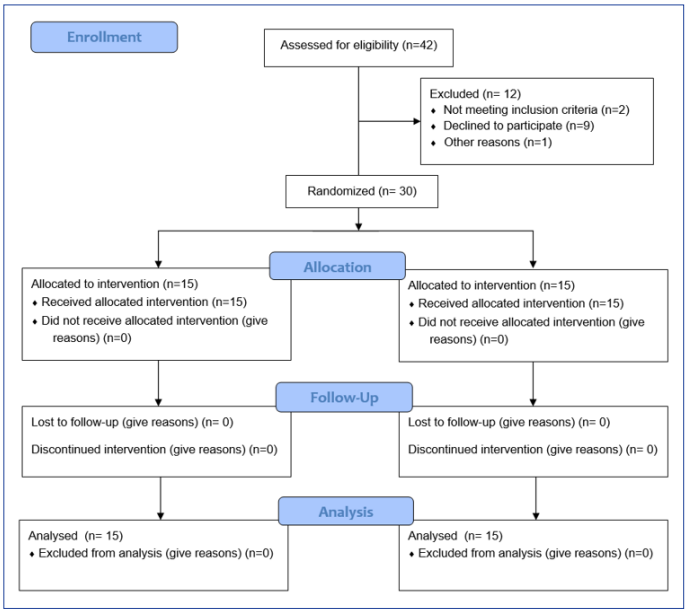

Figure 1. Participant Consort flow diagram of study.

It was determined that the post-treatment Mallet scores of global abduction, external, and internal rotation, reaching the mouth of both Groups 1 and 2 were significantly higher than the pre-treatment values ($p<0.001$) (Table 4 and Fig. 2). Mean and median values were used to compare the percentage changes which were non-normally distributed. Mann–Whitney U test, chosen to compare the not normally distributed data, revealed significant changes in favor of the Group 1 in reaching to the neck, reaching to the vertebra, and reaching to the abdomen which is shown in Table 5 ($p=0.02$, $p=0.039$, and $p=0.034$, respectively).

Mean the MA2 scores of ROM, accuracy, and dexterity increased significantly in the post-treatment period in both groups. Fluency was significantly better only in the Group 1 (Table 6 and Fig. 3).

The percentage of the change in ROM and fluency values were found to be significantly higher in Group 1 than that of Group 2 ($p=0.041$ and $p=0.006$, respectively) (Table 7).

The post-treatment accuracy scores of Groups 1 and 2 were significantly higher than the pre-treatment values but there was not a statistically significant difference between the two groups.

Discussion

In our study, we aimed to emphasize that functional improvement will be higher with CIMT protocol application in addition to conventional treatment than just conventional treatment in a patient with diagnosed with OBPP. The results of our study showed that CIMT in children with OBPP leads to a significant improvement of UE function ($p<0.001$), especially in abduction, external rotation, reaching to the back and the mouth. This finding is consistent with other studies. Similar, but less significant ($p<0.05$) improvements were also observed in the Group 2.

In the Group 1, the ROM, accuracy, fluency, and dexterity scores significantly improved after the treatment. In the Group 2, the ROM, accuracy, and dexterity scores significantly improved after the treatment; however, the change in the fluency scores was not found to be significant. When the MA2 scores of the two groups were compared, it was found that the percent changes in the two groups were not significantly different; however, the ROM and fluency had significantly increased in the Group 1.

We used a sling as CIMT equipment in our study. Techniques used to limit the unaffected limb in pediatric CIMT studies include tying the sleeve of a long-sleeved garment, wearing gloves with or without fingers, wearing a sling, a short or long arm plaster, and the forearm orthoses.[33] In a study by Werner et al. that included 21 patients, a cast ex-

Table 3. Demographic and functional characteristics and medical histories of the patients

	Group 1 (n=15) Mean(SD) or n-%		Group 2 (n=15) Mean(SD) or n-%		p
Age (months)	63.47±39.95		47.87±23.8		0.204[i]
Gender					
Male	4	26.67%	6	40.00%	0.439[f]
Female	11	73.33%	9	60.00%	
Birth weight (g)	3980±523 (3500–4680)		4065±476 (3500–4800)		0.645[i]
Child's education					
At home	10	66.67%	12	80.00%	0.291[c]
Preschool, Kindergarten	0	0.00%	1	6.67%	
School	5	33.33%	2	13.33%	
Can do overhead sports					
No	1	6.67%	2	13.33%	0.543[f]
Yes	14	93.33%	13	86.67%	
Gets help from caregiver during the play					
No	14	93.33%	13	86.67%	0.543[f]
Yes	1	6.67%	2	13.33%	
Care giver					
Mother	15	100.00%	15	100.00%	
Delivery method					
Vaginal	15	100.00%	14	93.33%	0.309[f]
Cesarean	0	0.00%	1	6.67%	
Preferred side					
Right	6	40.00%	6	40.00%	1[c]
Left	9	60.00%	9	60.00%	
The affected side					
Right	10	66.67%	9	60.00%	0.705[c]
Left	5	33.33%	6	40.00%	
OBPP type					
Narakas stage I-II	14	93.33%	14	93.33%	1[f]
Narakas stage III	1	6.67%	1	6.67%	
Operation history of brachial palsy					
None	12	80.00%	12	80.00%	1[f]
Present	3	20.00%	3	20.00%	
Previous history of PT					
No	7	46.67%	8	53.33%	0.715[c]
Yes	8	53.33%	7	46.67%	
Previous botulinum toxin injection					
No	15	100.00%	14	93.33%	0.309[f]
Yes	0	0.00%	1	6.67%	

SD: Standard deviation, PT: Physiotherapy, [i]:Independent t-test, [c]:Chi-square test, [f]:Fischer exact test.

tending from the fingertip to the axilla was used and it was emphasized that it was effective in the application of CIMT.[17] It is stated in the literature that the technique applied in CIMT treatment is not an important factor.[34]

In our study, we applied interventions to patients 4 days a week for 8 weeks. Different constraint periods have been reported for modified CIMT applications, ranging from 1 h and 24 h per day. The total duration of application varies between 10 days and 2 months.[31] Klingels et al. conducted a study with children with cerebral palsy where CIMT was administered for 10 weeks, 5 days a week, and 1 h per day.[23] Ehab et al. divided 30 participants with OBPP into two groups. The first group only underwent conventional exercise, whereas the second group also received CIMT for 12 weeks, 6 days a week, 2 h per day.[7] There is no definite application period and frequency in the literature.

In the literature, there are both case reports and group studies on the application of mCIMT which has the same treatment protocols as CIMT but includes less intense exercise programs and shorter duration for constrain to patients with OBPP.[1,7,34] In these studies, mCIMT was administered to two children aged 12 years with C5-C7 involvement and a child aged 2 years with C5-C6 involvement.[1,2] One of the 12-year-old children was restrained

Table 4. The comparison of Mallet scores before and after treatment

	Group 1 (n=15)	Group 2 (n=15)	p
Global abduction			
Pre-treatment	3.73±0.7	3.6±0.51	0.556[i]
Post-treatment	4.47±0.83	4.13±0.35	0.165[i]
P	0.0001[p]	0.001[p]	
External rotation			
Pre-treatment	3.27±0.88	3.27±0.59	0.999[i]
Post-treatment	3.67±0.9	3.53±0.52	0.623[i]
P	0.009[p]	0.041[p]	
Reaching to the neck			
Pre-treatment	3.14±0.77	3.2±0.68	0.833[i]
Post-treatment	3.93±0.8	3.53±0.52	0.115[i]
P	0.0001[p]	0.055[p]	
Internal rotation (reaching to the vertebrae)			
Pre-treatment	3.2±0.77	3.13±0.74	0.812[i]
Post-treatment	4±0.65	3.47±0.74	0.076[i]
P	0.0001[p]	0.019[p]	
Reaching to the mouth			
Pre-treatment	3.27±0.88	3.2±0.86	0.836[i]
Post-treatment	3.93±0.59	3.47±0.74	0.068[i]
P	0.003[p]	0.041[p]	
Internal rotation (reaching to the abdomen)			
Pre-treatment	3±0.65	2.93±0.59	0.772[i]
Post-treatment	3.73±0.88	3.2±0.68	0.074[i]
P	0.0001[p]	0.041[p]	

[i]: Independent t-test, p: Paired t-test.

for 6 h a day for 3 weeks, with the sling extending to the fingers from the proximal forearm. The other child was constrained for 4.5 weeks, 4 h per day. Three weeks after the exercise program, which included daily activities, there was an increase in the hand strength and pronation/supination scores in both patients.[1] The 2-year-old boy was found to have increased hand strength and bimanual use after the 14-week constraint and shaping therapy, with the unaffected extremity bound for 30 min

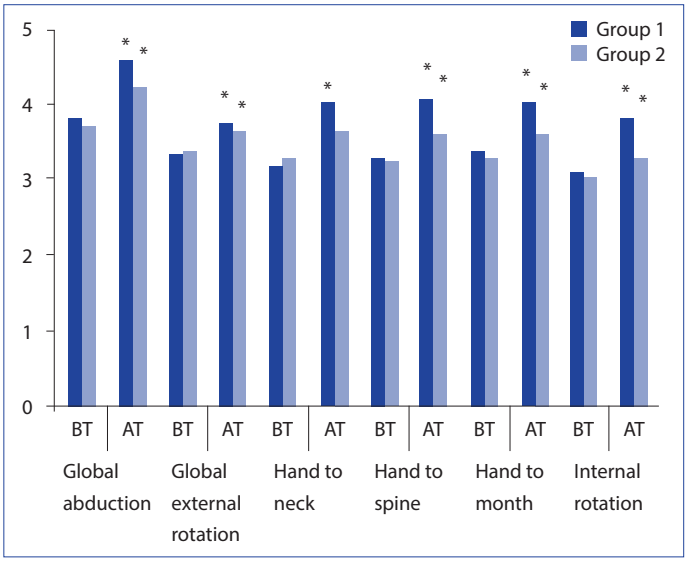

Figure 2. The comparison of Mallet scores before and after treatment.

*: Statistically significant; BT: Before Treatment; AT: After Treatment.

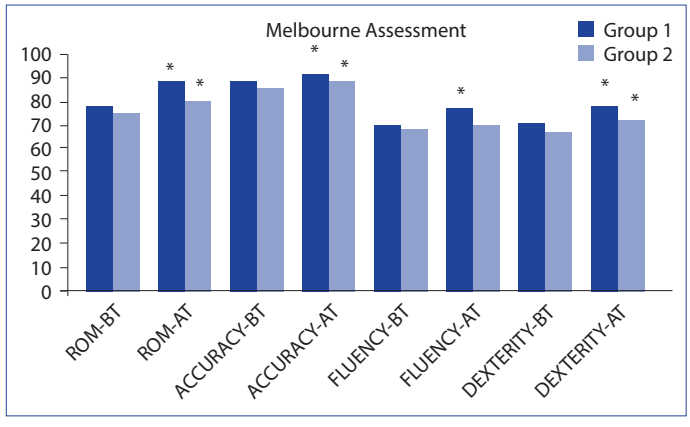

Figure 3. The comparison of Melbourne Assessment -2 scores before and after treatment.

*: Statistically significant; BT: Before Treatment; AT: After Treatment.

Table 5. The comparison of the changes (%) between pre-and post-treatment Mallet scores

Pre-treatment/post-treatment change (%)	Group 1	Group 2	p
Global abduction			
Mean±SD	15.33±12.32	12.67±12.37	0.998[m]
Median (IQR) *	20 (0–20)	20 (0–25)	
External rotation			
Mean±SD	10.22±13.21	7.22±12.55	0.533[m]
Median (IQR)	0 (0–25)	0 (0–25)	
Reaching to the neck			
Mean±SD	22.14±11.88	8.89±16.2	0.02[m]
Median (IQR)	25 (20–25)	0 (0–25)	
Reaching to the vertebrae (internal rotation)			
Mean±SD	21±12.85	8.89±13.16	0.039[m]
Median (IQR)	25 (20–25)	0 (0–25)	
Reaching to the mouth			
Mean±SD	17.67±18.98	7.78±13.53	0.143[m]
Median (IQR)	25 (0–25)	0 (0–25)	
Reaching to the abdomen (internal rotation)			
Mean±SD	18±11.31	7.22±12.55	0.034[m]
Median (IQR)	25 (0–25)	0 (0–25)	

IQR: Interquartile range, SD: Standard deviation, [m]: Mann-Whitney U test.

Table 6. The comparison of the MA2 scores before and after treatment

	Group 1 (n=15)	Group 2 (n=15)	p
ROM			
Pre-treatment	80.25±15.88	77.28±15.33	0.607[i]
Post-treatment	90.86±9.69	81.73±13.09	0.038[i]
P	0.0001[p]	0.001[p]	
Accuracy			
Pre-treatment	89.33±15.17	88±15.12	0.811[i]
Post-treatment	93.87±10.68	90.93±15.67	0.554[i]
P	0.008[p]	0.028[p]	
Fluency			
Pre-treatment	72.06±12.71	69.84±12.56	0.634[i]
Post-treatment	79.37±14.02	72.06±13.21	0.153[i]
P	0.0001[p]	0.110[p]	
Dexterity			
Pre-treatment	72.63±18.47	68.77±18.71	0.574[i]
Post-treatment	79.65±16.27	72.98±17.21	0.285[i]
P	0.0001[p]	0.028[p]	

The MA2: Melbourne unilateral upper limb assessment-2 Scale, i: Independent t-test, p: Paired t-test.

per day.[2] In another case report, botulinum toxin-A injection was performed to prevent biceps-triceps contraction of two children aged 6 and 7 years who were diagnosed with Erb-Duchenne Palsy. Subsequently, they were treated with mCIMT 30 min per day for 2 months. Functional gains have been reported with this treatment.[34] In a randomized controlled study of 39 patients by Eren et al., it was concluded that mCIMT was effective in improving functional status and was recommended for use in routine clinical practice.[35]

We made our measurements for the MA2 and Mallet scale on the video recordings. Ehab et al. have conducted a study where they used the Mallet scale and the universal goni-

Table 7. The comparison of the changes (%) between pre-and post-treatment the MA2 scores

	Group 1	Group 2	p
ROM			
Mean±SD	12.54±11.67	6.16±7.54	0.041[m]
Median (IQR)	8 (4.76–16.67)	4.76 (0–8.33)	
Accuracy			
Mean±SD	5.67±9.11	3.03±4.7	0.386[m]
Median (IQR)	4 (0–8.33)	0 (0–4.76)	
Fluency			
Mean±SD	8.77±6.59	2.76±6.13	0.006[m]
Median (IQR)	6.25 (5.56–12.5)	0 (0–0)	
Dexterity			
Mean±SD	10.41±10.27	7.05±11.86	0.170[m]
Median (IQR)	6.67 (5.88–14.29)	0 (0–8.33)	

The MA2: Melbourne unilateral upper limb assessment-2 Scale, IQR: Interquartile range, SD: standard deviation, m: Mann–Whitney U test.

ometer. They found that the post-treatment values of both groups were significantly higher than the pre-treatment values; however, the results in the CIMT group were significantly better.[7] It is recommended that the MA2 assessment be done with video recording, not live. In this way, the level of inter-rater reliability increases and this raises the reliability of the test.[36]

The MA2, which includes video recording, takes 30–45 min depending on the age and attention span of the child. It evaluates the quality of UE movements. In the literature, few studies have chosen the MA2 to monitor the functional outcome. In our research, we chose to use this method to observe the daily activities and skills of a child on video recordings which enable filtered and repeated observation.[37]

We applied the first intervention in the rehabilitation unit with the supervision of a physiotherapist. Besides, we trained the patient's caregiver and exercises were repeated at home. In the literature, CIMT has been applied in different environmental settings such as home, kindergarten, day camp, or clinic.[27] Some researchers emphasize that it would be more effective to limit the natural environment of the child, such as home or kindergarten, to facilitate learning whereas some others indicate that it should be practiced in a clinic, not to affect the family's life and tasks.[27] In a study of children with cerebral palsy, Chen et al. found that home-based modified CIMT was more effective than traditional rehabilitation methods.[38]

In our study, the treatment was found to result in positive changes in the joint ROM, function, skill, and speed of the affected limb. The improvements were superior to conventional rehabilitation exercises.

Limitation and Strength of Study

Limitations of the study include the small sample size, the short duration, and the fact that CIMT was applied at home. The strengths of the study include the randomized controlled design of the study, the limited duration of CIMT, the child-friendly nature of the application, and the orthosis and also a video recording of the activities. It should be noted that there are very few controlled randomized trials in the literature concerning this subject. The patient was not blinded due to the nature of the study. However, the physician that evaluated the patient was blinded, which improved the objectivity of the study.

Conclusion

Modified CIMT was considered to be an effective treatment to improve the UE ROM and function among children with OBPP. There were no complications associated with CIMT, such as falling, joint contracture, decreased function of the unaffected limb, or skin irritation. For this reason, it was concluded that it might be useful for the routine rehabilitation process to include CIMT. Applying CIMT at an early age might be more effective due to higher neuroplasticity.

Further studies are needed to determine the most appropriate age group for CIMT among children with OBPP, the most effective protocol, and the long-term effects of CIMT. Studies including fMRI can be used to evaluate the peripheral effects of CIMT, and to visualize the effects on electrophysiological, spinal, and cortical representation.

Disclosures

Ethics Committee Approval: Ethical Committee of Şişli Hamidiye Etfal Training and Research Hospital, Decision no/date: 240/2014.

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