

Effect of constraint-induced movement therapy in reducing severity of mirror movements in children with unilateral spastic cerebral palsy

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Abstract

To determine the effect of constraint-induced movement therapy (CIMT) in improving hand function and reduction in severity of mirror movements in children with unilateral spastic cerebral palsy who have mirror movement disorder. Spastic hemiplegic CP children of either gender, aged 6 to 16 years, with mirror movements of grade 1 and 2 who were able to make a gross grip, were included in this single arm feasibility study. CIMT was provided as an intervention to these children for six hours per day for 15 consecutive week days. Woods and Teuber criteria was applied for the assessment of mirror movements. Pre- and post-intervention assessment results showed that there was improvement in the unimanual and bimanual hand function in CP-affected children ($p < 0.05$) and reduction in the severity of mirror movements ($p < 0.05$). Constraint-induced movement therapy improved hand function and reduced the severity of mirror movements in children with unilateral spastic cerebral palsy.

Keywords: Cerebral palsy, Mirror movement disorder, Physical therapy, Rehabilitation.

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Introduction

Cerebral palsy (CP) is a group of disorders of movement and posture causing limitations in activities of daily living. It is a common cause of childhood disability with a prevalence of 0.6-1 per 1,000 births. Most of children face problems in the execution of bimanual activities of daily living and the main reason for this is poor function of the paretic hand due to which the use of non-paretic hand in various bimanual tasks is increased.¹ Major causes of CP are congenital, genetic, infectious, and traumatic. Prenatal injury causes 70-80% of the cases with less than 10% caused by significant birth trauma.²

Cerebral palsy includes some movement disorders like tremors, myoclonus, ballism, tics, and mirror movements. Mirror movements are simultaneous involuntary

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contralateral identical movements of one hand that occur with the voluntary movements of the other hand. It involves hand and fingers for example, making fist with the right hand followed by the left hand.³ Frequency of mirror movements is 35.7% in spastic cerebral palsy children with most of the MM observed in grade 1 and 2 of Woods and Teuber criteria.⁴ The pathomechanism of these MM in most of the cases lies in a peculiar type of corticospinal organisation. The brain lesion disrupts the normal crossed corticospinal projections from the lesioned hemisphere, the contralesional hemisphere preserve its normal transient ipsilateral corticospinal pathway. Thus, the two hands are controlled by the same hemisphere.^{5,6}

Mirror movements have a negative impact on hand performance, both unimanual and bimanual, and also affect the functional independence of children with spastic cerebral palsy.^{7,8}

Literature search revealed that few studies have been done providing intervention to CP children with MM to observe reduction in severity of mirror movements, improvement in hand performance, and functional independence. Constraint induced movement therapy is effective in improving gross and fine motor skills^{9,10} but no study has been done to observe its effect in improving functional independence and reducing the severity of MM in children with spastic cerebral palsy with mirror movement disorder. CIMT includes restriction of the non-affected hand with a sling and encourages the use of the affected hand to perform the activities.¹⁰ The current study was planned to provide CIMT to spastic cerebral palsy children with mirror movements to observe its effect on hand performance, functional independence, and reduction in the severity of MM.

Patients/Methods and Results

The single arm feasibility study (non RCT) was conducted at Al Farabi Special Education School, Islamabad, Pakistan, from March 2019 to June 2019 and included spastic hemiplegic children of either gender, aged 6 to 16 years, who had active wrist extension, thumb abduction, and extension of any two digits of 10 degrees, 5 had mirror movements of grade 1 and 2 according to Woods and Teuber criteria.⁶ Those excluded were low tone CP children,

those not able to follow command, children having spasticity of grade 3 and 4 according to modified Ashworth scale⁶ and children with level IV and V on manual ability classification scale.⁸

The sample size was calculated using Open Epi tool with anticipated population of 0.01.4 Permission was taken from the director of the school concerned and written consent was taken from the parents of the children to participate in the study.

Nine participants who met the eligibility criteria were included in the study. They were provided CIMT for six hours per day for 15 consecutive days (90 hours). Pre-intervention assessment was done with Woods and Teuber criteria to measure mirror movements (ICC greater than 0.82)⁵ that consists of three tasks (fist opening and clenching, finger opposition, and finger tapping) and five grades: grade 0 (no clear mirror movement), grade 1 (barely discernible repetitive movement), grade 2 (showing slight mirror movement or stronger short time), grade 3 (stronger and sustained mirror movement), grade 4 (mirror movement equal to opposite hand).⁵ Each task was performed with the participant sitting comfortably with elbows and forearm supported on the table. Video was made of all the participants while performing the tasks in order to confirm the presence and absence of MM. To check the functional independence of children Manual ability classification scale, a valid tool (ICC equal to 0.97) was used that consist of five levels: level I (handles objects easily and successfully) level II (reduced quality and somewhat reduced speed of achievement), level III (help to prepare or modify activity), level IV (limited selection of easily managed objects in adapted situations), and level V (does not hold any object).⁷ To assess the unimanual hand function, a valid tool Jebson Taylor hand function test (JTHFT)⁶ that consist of seven components (writing, simulated page turning, feeding, stacking checkers, picking up small objects, lifting large light objects, and lifting large heavy objects) was used. To measure the bimanual hand function of children, a set of bimanual activities of daily living was used, for which five activities were performed such as carrying a tray, cutting a fruit with a knife, holding and cutting the paper with scissor, buttoning and knotting. There are four grades: grade 0 (non-existent), grade 1 (assisting without grip), grade 2 (assisting with alter grip), and grade 3 (normal).⁹

About 15 to 20 minutes were spent on one participant for data collection. After baseline assessment, children were divided into three groups with three children in each group. CIMT was provided to children which included the restriction of a less paretic hand with a sling for six hours per day for 15 consecutive weekdays (adjusted for holidays;

90 hours) in the physiotherapy room of the school.^{10,11} Well-trained physiotherapists provided the intervention under the supervision of the class teacher of each student. Participants were engaged in different fine and gross motor group activities that elicit general movement of interest and included a range of age-appropriate, unimanual functional and play activities such as painting, building a tower with blocks, making bubbles, picking up coin games, and playing different card games. After 15 days of CIMT, final assessment was done with Woods and Teuber criteria, MACS, JTHFT, and bimanual activities of daily living.¹²

Of the nine participants, 6 (66.6%) were boys and 3 (33.3%) were girls. The overall mean age was 10.11±2.422 years; 5(55.5%) were right hemiplegic, and 4(44.4%) were left hemiplegic. Most of the participants had grade 2 MM measured by Woods and Teuber criteria. Seven participants had level III and two participants had level II on MACS.

To check the normality of all variables Shapiro Wilk test was applied, which indicated normal distribution of JTHFT and bimanual activities of daily living, while Woods and Teuber criteria and MACS were skewed.

For normal variables, Paired T-test was applied, for JTHFT there was a significant difference in the unimanual hand function of children ($p < 0.05$) in both hands. Bimanual activities of daily living observed improvement in bimanual hand function of children ($p < 0.05$) (Table -1).

For skewed variables Friedman Test was applied; Woods and Teuber criteria shows a significant difference in all three task (fist making, finger opposition, and tapping) as $p < 0.05$. There is reduction in the severity of mirror movements from grade 1 and 2. There is a significant difference in the functional independence of children as ($p < 0.05$) for Manual ability classification scale. As highest frequency of MACS was level III in CP children this means that children improved the level and overall functional independence. (Table- 2)

Findings showed that CP children with mirror movement improved hand function, functional independence, and observed decrease in severity of MM. Adler C et al⁴ conducted a qualitative assessment of MM in children with spastic hemiplegic CP. The study investigated whether

Table-1: Paired T test showing value of JTHFT (right, left hand) and bimanual activities of daily living.

Scales	Baseline Mean±SD	After CIMT Mean±SD	p-value
Jebson Taylor hand function test (right)	168.2±40.97	139.12±56.8	0.01*
Jebson Taylor hand function test (left)	144.3±34.81	130.54±39.9	0.04*
Bimanual activities of daily living	11.01±1.93	13.71±2.94	0.009*

JTHFT: Jebson Taylor hand function test; SD: Standard Deviation.

Table-2: Friedman test showing value of Wood and Teuber criteria and MACS.

Scales	Baseline	After CIMT	p-value
	Mean ranks	Mean ranks	
Wood and Teuber (fist)	2.50	1.39	0.006*
Wood and Teuber (opposition)	2.44	1.61	0.022*
Wood and Teuber (tapping)	2.46	1.55	0.008*
MACS	2.89	1.33	0.001*

MACS: manual ability classification scale

these MM had any negative impact on bimanual activities of daily living. Woods and Teuber criteria were used to measure the mirror movements, JTHFT was used to assess the performance of unimanual tasks, while a set of five bimanual activities of daily living was used to evaluate bimanual tasks. Three weeks of intensive training was provided to 11 unilateral spastic CP children with mirror movements (age six to 17 years). Goal-oriented therapy focusing on bimanual activities and functional exercises improved hand performance, but there was no reduction in the intensity of mirror movements in children.⁴ In the current study, CIMT was provided to spastic hemiplegic CP children (age six to 16 years) with mirror movements for six hours per day, 15 consecutive days (90 hours). CIMT not only improved hand function and functional independence but also reduce the severity of mirror movements in children.

Araneda et al¹¹ investigated potential changes in MM after Hand and Arm Bimanual Intensive Therapy including Lower Extremity (HABIT-ILE) in children with unilateral CP (mean age nine years). Children were assessed three times: before (baseline), after two-week interval, and again at three months as follow-up. HABIT-ILE training was provided for 90 hours.¹¹ The study concluded that HABIT-ILE decreased the intensity of mirror movements and mirror movement changes were associated with bimanual performance and activities of daily living in children.

Andrew et al¹² provided Constraint-induced movement therapy to hemiplegic cerebral palsy for 90 hours, six hours per day for 15 consecutive weekdays and observed improvement in hand function specifically in paretic hand. Our intervention approach is in line with this study, CIMT improved the bimanual hand function and also reduced the intensity of mirror movements in children.

The participants responded well to the intervention which we believe was due to the playful activities throughout the sessions. The current study has marked limitations like unequal gender distribution, only hemiplegic cerebral palsy was included, there was no follow-up after the therapy, and small study duration. The findings of the intervention need to be interpreted with caution as rigorous methods were not used. Future studies should

design a specific therapeutic programme to improve hand performance and to decrease the intensity of mirror movements in children with cerebral palsy.

Conclusion

Hand function of children with mirror movements improved with improvement in functional independence, while reduction in severity of mirror movements was observed after receiving constraint-induced movement therapy for 15 consecutive days (90 hours).

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Author Contribution:

JS: Designing, literature review, writing proposal, permission from the respective centre, data collection and analysis, interpretation and writing, formatting of the manuscript.

AMH: Methodology and supervision of data collection procedure, data analysis and interpretation, final approval.

HK: Writing the results, and drafting the work.