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Original Article

Effects of Expanded Constraint-Induced Movement Therapy on Hand Function in Children with Cerebral Palsy: A Randomized Controlled Trial

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Abstract

Background: Hemiplegic cerebral palsy children can attend schools regularly, but due to impairment of upper limb function, participation is restricted in leisure and educational tasks and it affects their social and functional activities. Constraint-induced movement therapy is specifically used for the upper extremity and can enhance cerebral palsy children's hand function. **Objective:** To evaluate the effectiveness of expanded constraint-induced movement therapy on hand function in children with cerebral palsy. **Methods:** A single-blinded randomized controlled trial was conducted at the department of Physical Therapy, Children's Hospital, Lahore, Pakistan from December 2021 to April 2022 using non-probability convenient sampling. Children with hemiplegic cerebral palsy aged between 5 and 12 years were randomly allocated into two groups (22 patients per group), the experimental group treated with expanded constraint-induced movement therapy and routine physical therapy and the conventional group treated with routine physical therapy only. The pediatric motor activity log scale and Wolf motor function test were the outcome measuring scales. The trial was approved by the ethical committee of the hospital and registered prospectively in the clinical trial registry of the US (ClinicalTrials.gov trial ID 57520). **Results:** As compared to the conventional group, the score of the pediatric motor activity log scale improved significantly (p-value ≤0.001) in the experimental group. Participants showed significant differences for both domains of the wolf motor function test in the experimental group as compared to other groups and they showed significant improvement in hand function (p≤0.001) within the groups. **Conclusion:** Expanded constraint-induced movement therapy along with routine physical therapy is found to be more effective in improving the function of the pelagic hand in children with hemiplegic cerebral palsy.

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Introduction

Cerebral palsy (CP) term specifies the motor disorders that often coincide with musculoskeletal, epilepsy, communication problems, behavioral problems and difficulties with cognition, perception and sensation. CP is a type of irreversible disorder of posture and movement, and it causes limitation of activity and is associated with conservative disruption which occurred in the infant's brain or developing fetus. CP is considered the major disability of childhood and approximately presents with a prevalence of 2.1 per 1000 lives birth. In the United States, the prevalence is 3 to 4 per 1000 children.[1] Hemiplegic CP children mostly have the cerebral capacity to attend schools regularly, but due to impairment of upper limb function, participation is restricted in leisure and educational activities thus affecting their social image.[2]

Flexed upper limb, retracted scapula, depressed shoulder girdle, shoulder joint internally rotated and adducted, elbow joint flexion and pronated forearm, flexion and slight ulnar deviation of the wrist, fingers and thumb are some of the common disabilities. Hand function is impaired in the entire disease categories and it affects the quality of life and functional independence of the child.[3] Hand impairment is also the outcome of destruction to the corticospinal and motor cortex pathway that is accountable for the skills control of the finger and hand.[4] Areas associated with bimanual coordination include the supplementary motor area and parietal lobe, which are commonly associated with hemiplegic brain damage.[5] There is a coupling of movements during symmetrical bilateral CIMT that is efficacious and used in high dosage and this rehabilitation approach is commonly used nowadays for hemiplegic CP children.[6]

CIMT aims to increase daily use of the affected upper limb and to maximize the effects of learned nonuse.[7] CIMT has four main components, which are intensive training, organization, behavioral techniques and patted mitt. The purpose of these components is to learn the usage of non-used extremities. The interventions used are expanded constraint-induced movement therapy (eCIMT) which includes instruction of adaptive equipment, orthotics and elements of other rehabilitation therapies.[8] Baby CIMT is found to be more effective in improving the unilateral ability of young children with unilateral CP than massage.[9]

A systematic review was conducted to review the effectiveness of CIMT in participation and improving the function of the upper limb in hemiplegic CP and it concluded that CIMT was found to be more effective as compared to sham treatment in improving upper limb activity in hemiplegic CP children.[2]

In another systematic review, virtual reality games along with the conventional physical therapy are found to be very effective and produce significant changes in motor functions in patients with cerebral palsy.[10]

Another study found that mCIMT can improve isolated functions of the paretic arm better than bimanual training.[11] Pediatric CI therapy produces more improvement in motor function for young children with this disorder [12]. Another RCT showed that a non-intensive form of home-based CIMT was found to be effective in treating the affected upper limb of a CP child.[13] In most of the published studies, interventions were carried out using CIMT and modified CIMT on upper limb function in hemiplegic CP children. The CIMT technique is only used for the upper extremity and it can enhance cerebral palsy children's hand function. The study on expanded constraint-induced therapy was conducted in stroke

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patients with pelagic hands but there is limited literature being conducted on children with pelagic hands. Therefore, a study is needed to evaluate the effects of eCIMT on pelagic hand function in hemiplegic cerebral palsy children.

Methods

In this single-blinded controlled trial, 44 participants were recruited from the Physiotherapy department of Children's Hospital Lahore, Pakistan with a 95% confidence interval, statistical power of 80%, having mean pediatric motor activity log scale (PMAL) score of 1.3 and 2.2 and standard deviation (SD) of 0.5 and 1.3 in experimental and control groups respectively.[14] Sample size was calculated using open epitool software. The sample size of 38 patients was calculated with 19 patients in each group, [15] by using the formula: $n=2\sigma^2 (z_{1-\alpha/2} + z_{1-\beta})^2/(\mu_1 - \mu_2)^2$

Desired Power of the study = β =80%
Desired Level of Significance = α = 95%
Expected Mean Difference in toxicity = μ 1- μ 2 =1.3-2.2 =-0.9
Standard Deviation of PMAL in Group 1 = δ1= 0.5
Standard Deviation of PMAL in Group 2 = δ2= 1.3
Sample size in each group = n = 19
Final sample size after adding 20% attrition rate: 22

These participants were then randomly allocated into two groups (22 patients/group), the experimental group was treated with eCIMT and routine physical therapy (RPT) and the conventional group had been given routine physical therapy only. The trial protocol of this study was approved by the ethical committee of the Hospital and registered prospectively in the clinical trial registry of the US (ClinicalTrials.gov trial ID 57520). Six participants left the trial at an early stage, which is why only 38 participants were analyzed and treated. Children aged between 5-12 years, both gender, diagnosed with spastic hemiplegic cerebral palsy by the neurologist were included in the study. Consent to participate in the trial was taken from their parents/guardians. Selected participants were involved in non-usage of the more affected upper extremity and with minimal ability to actively stabilize and grasp an object with the more affected hand.[4,8,16] Children with a known case of seizures and visual problems that could interfere with the treatment,[4] children that had paretic hand surgery within the past year, children suffering with severe sensory or cognitive disorder, or malignancy, any major as well as minor nerve blockage or surgery in the previous six months before the exposure to CP were excluded from the study.[3] To assess the hand function, the PMAL scale and Wolf motor function test (WMFT) were used.

The PMAL scale is used to assess the ability of the child to use his/her affected arm. It consists of 22 items; 0 means that the weaker arm was not used by the child for the activity and 6 means the child's weaker arm did the activity normally. The first scale rated how often a child carries out each activity with his/her impaired arm. The second scale rated how well the child makes use of his/her involved arm for each activity.[14] WMFT is used to assess functional limitation of the upper extremity and is a valid and reliable measure of assessing the motor ability of the upper extremity through functional and timed tasks.

It consists of 17 items, which include three main components: functional ability, time and strength. Functional ability scale (FAS) is used to test the upper extremity and it consists of 5 scales where 0 means do not attempt with the upper extremity being tested and 5 means normal movement.[17] Participants had a detailed screening and examination for

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assessing eligibility in the inclusion and exclusion criteria, after giving informed signed consent by parents. The outcome assessor was unaware of the group allocation. Participants were assessed at baseline and then re-assessed on the outcome scales at end of treatment i.e. after 3 weeks by the same investigator. Investigator found the participants highly motivated at the end of three weeks. The treatment was provided at the physiotherapy department six days per week on daily basis, for three weeks (18 sessions). The detailed neurological examination, screening as well as pre and post-assessments of intervention and outcome measures were performed by different researchers.

In the experimental group, the eCIMT protocol involved neurodevelopment techniques (NDT), electromyography-functional electrical stimulation (EMG-FES), orthotic, splints & adaptive equipment, and bimanual task practice with simulated daily activities.[18] NDT included manual stretching for elbow and wrist with 2 sets of 10 repetitions. The upper extremity weight bearing program included prone lying and weight bearing on forearms over a prone wedge, on forearms over a bolster and on hands over a foam block or when lying on an inclined plane and over a physiotherapy ball. Each position was maintained for 30 seconds.[19] EMG-FES in which electrical stimulation was used on the affected hand, and was applied to the extensors of wrist muscles for 10 minutes, consecutive six days a week.[20]

Orthotics or splints were used for the affected hand to maintain the fingers as well as wrist in finer alignment and it was customized for each participant according to individual needs.[4] Bimanual task practice includes dough activities, bottle and marble activities and manual tasks. RPT included stretching, strengthening and functional exercises of the upper extremities.[18] Both groups were having a treatment session of one hour.

The treatment was provided for consecutive six days a week. Statistical package for social sciences (SPSS) version 22 was used to enter and analyzed the data. The numerical data like age was presented in the form of mean ± SD. Qualitative data like gender and group were presented in the form of frequency (percentage). The normality of the data was assessed with the Kolmogorov-Smirnov test. The parametric test was applied as data were found normally distributed. Between-group comparison before and after treatment was done with the help of an independent sample t-test. Paired sample t-test was exerted to see the difference in outcome measures before and then after treatment within treatment groups. A p-value of ≤ 0.05 was considered significant.

Results

Demographics of study participants were mentioned in Table I. Comparison of PMAL score pre and post-test between both groups showed significant improvement as the p-value was found as ≤ 0.001 in the experimental group with eCIMT as compared to the conventional group without eCIMT (Table II). Participants improved significantly ($p \leq 0.001$) for both the domains of WMFT with FAS and performance time (PT) in the conventional group as compared to the experimental group (Table IV). Table IV showed that there is no significant difference in the mean values of WMFT-FAS and WMFT-PT at baseline between both groups as the p-value was not significant. Participants show a significant difference (≤ 0.001) in PMAL and WMFT scores within both groups (Tables III and V).

Discussion

The present study evaluates the effects of the expanded form of constraint-induced

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movement therapy on the pelagic hands of hemiplegic CP children. Clinical and demographic characteristics of participants of both groups were quite similar which showed that both groups were comparable. The study results showed that eCIMT is an effective treatment as compared to routine physical therapy alone in improving the hand function of hemiplegic children. The findings of our study are following the published literature in which an expanded form of constraint-induced movement therapy was applied to the pelagic hands of stroke patients and eCIMT was found more effective as compared to the routine treatment approach in improving the function of the more affected upper paretic hand after

Figure I: Flow of participants throughout the trial (CONSORT diagram)

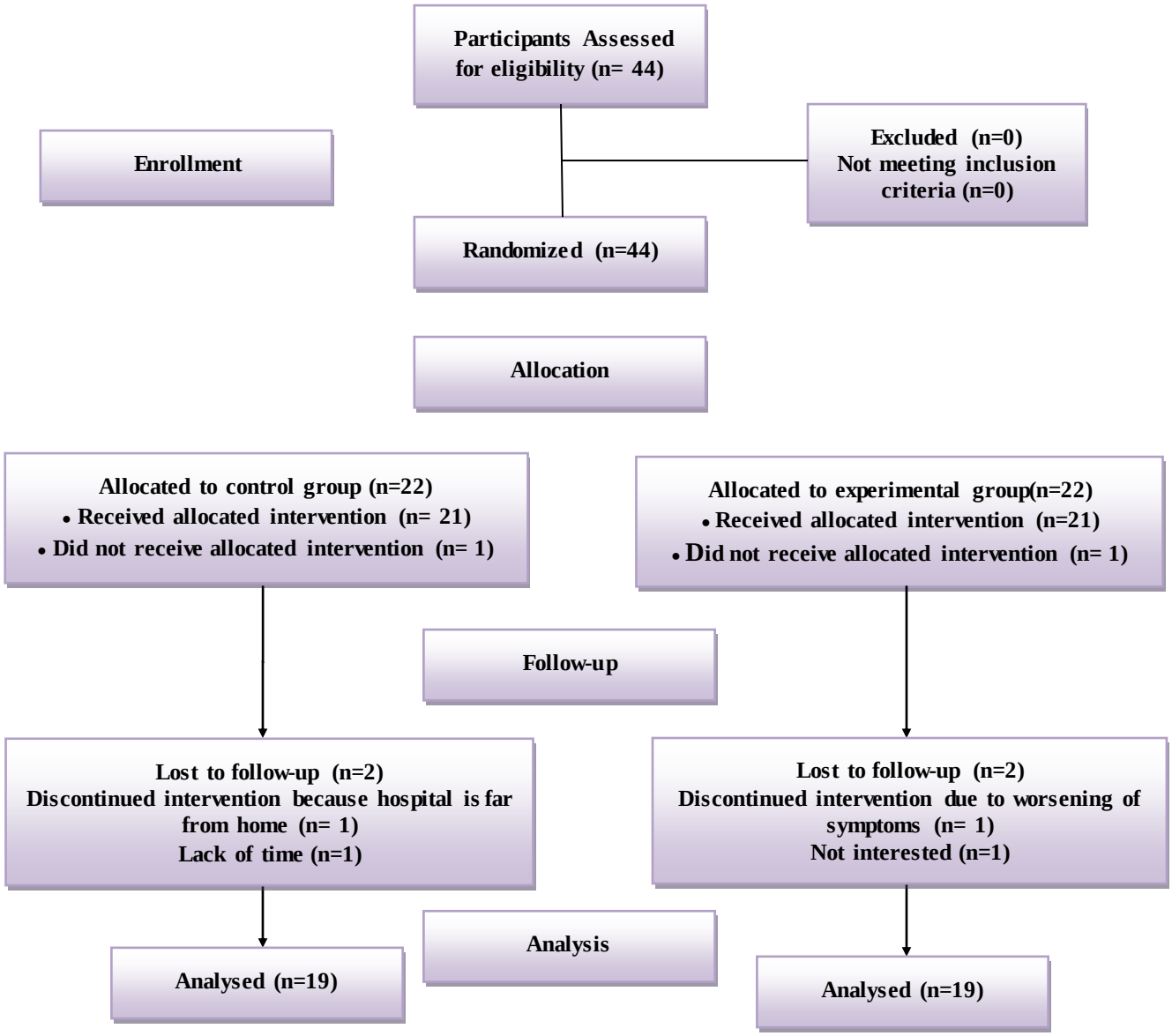

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Table I: Demographics of Study Participants (n=38)

Characteristics	Conventional group	Experimental group
Age (years)	6.89+2.02	7.68+2.49
Male	10(52.6%)	05(26.3%)
Female	09(47.4%)	14(73.7%)
Right Upper Extremity	11(57.9%)	13(68.4%)
Left Upper Extremity	08(42.1%)	06(31.6%)

Table II: Comparison of Pediatric Motor Activity Log Scale (PMAL) Pre and Post-Treatment Between Groups

Outcome Measures	Groups	n	Mean	SD	Mean Diff.	p-value
Pre-test PMAL score	Conventional Group	19	0.71	0.54	0.10	0.485
	Experimental Group	19	0.60	0.30		
Post-test PMAL score	Conventional Group	19	1.91	0.52	-1.48	0.000
	Experimental Group	19	3.37	0.42		

Table III: Comparison of Pediatric Motor Activity Log Scale (PMAL) Pre and Post-Treatment Within Groups

Outcome Measures		n	Mean	SD	Mean Difference	p-value
Pair 1	Pre-test PMAL	38	0.66	0.44	.07	.000
	Post-test PMAL	38	2.64	0.87	.14	

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Table IV: Comparison of Wolf Motor Function Test (WMFT) Pre and Post-Treatment Between Groups

Outcome Measures	Groups	N	Mean	SD	Mean Difference	p-value
Pre-test WMFT-FAS	Conventional group	19	12.53	8.25	-2.79	.214
	Experimental group	19	15.31	4.91		
Post-test WMFT-FAS	Conventional group	19	29.10	10.40	-29.47	.000
	Experimental group	19	58.58	5.42		
Pre-test WMFT-PT	Conventional group	19	79.35	8.21	0.28	.933
	Experimental group	19	79.08	11.61		
Post-test WMFT-PT	Conventional group	19	59.08	9.13	.23.79	.000
	Experimental group	19	35.29	7.76		

Table V: Comparison of Wolf motor function test (WMFT) pre and post-treatment within groups

Test Statistics		
	Pre-test WMFT PT and WMFT FAS	**Post-test WMFT PT and WMFT FAS**
Z	-5.373[b]	-.544[b]
Asymp. Sig. (2-tailed)	.000	.587
a. Wilcoxon Signed Ranks Test		
Sb. Based on negative ranks		

15 weeks of treatment.[18] Another study supports the result of our study which was conducted on hemiplegic CP children to evaluate the effects of modified CIMT on hand function. Compared to our research the sample size of this study was less and it included children between the age of 2 to 8 years. And treatment time was three hours and PMAL was used as an outcome-measuring tool as that in the current study. The results of this study showed clinically and statistically significant improved hand function in the group with modified CIMT.[4]

The results of our study are also supported by a systemic review in which the effectiveness

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of CIMT on hand function is compared with sham or no intervention in children with cerebral palsy.[2,21,22] The previous research conducted on hemiplegic children showed improvement in the function of the upper limb by using the CIMT technique at 10 weeks.[23] Another systematic review was conducted to evaluate whether CIMT is beneficial in improving the upper extremity of CP children. It is found helpful in treating hemiplegic CP children.[24] A review was conducted in CP children to check the effect of CIMT on the upper limb.

Some articles were not relevant and duplicated and these articles were excluded from the research. The results of articles included in this study showed that CIMT is affected when compared to another group receiving no intervention but further research was needed to evaluate whether CIMT is effective in improving muscle tone and protective extension.[25] CIMT is also effective in infants who are younger than one year with unilateral CP. Compared to baby massage, baby CIMT is found more effective in infants between ages 3-8 months.[26]

Some previous studies were conducted to compare the CIMT and hand-arm bimanual intensive therapy (HABIT) in hemiplegic CP children. HABIT is a bimanual training in children that includes both affected and unaffected hands.[27] Compare to our research only the affected hemiplegic hand was assessed. Another study included modified CIMT compared with HABIT.[28] This study is limited to a single hospital setting in Lahore, Pakistan, so the results cannot be generalized to the whole population. Patients were recruited by a non-probability convenient sampling technique that can be a cause of biasness in the study results. This study did not document the physical activities of children and their use of effected arm at home.

Conclusion

Expanded constraint-induced movement therapy along with routine physical therapy is more effective in improving the function of the pelagic hand in children with hemiplegic cerebral palsy as compared to routine physical therapy.

Declarations

Consent to participate: Written consent had been taken from patients. All methods were performed following the relevant guidelines and regulations.

Availability of data and materials: Data will be available on request. The corresponding author will submit all dataset files.

Competing interests: None

Funding: No funding source is involved.

Authors' contributions: All authors read and approved the final manuscript.

CONSORT Guidelines: All methods were performed following the relevant guidelines and regulations.

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