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Effectiveness of Constraint Induced Movement Therapy and Bimanual Therapy in Children with Hemiplegic Cerebral Palsy

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Abstract: ***Introduction: The hemiplegic cerebral palsy (CP)is one of the disorders that involve paralysis on one side of the body. It is characterized by impairments of motor function of upper and lower extremities that involves unimanual and bimanual function of upper extremity. The constraint induced movement therapy (CIMT) and bimanual therapy promotes the unimanual and bimanual function and other function of upper extremity. The objectives of this study were-to find out and compare the effectiveness of CIMT and bimanual therapy in muscular tonicity, unimanual function, bimanual function, handle objects and in weight bearing in different position (prone lying, cross-leg sitting, 4-point kneeling) and protective extension in side and backward. Methodology: This study was an experimental type of design. Total 20 participants were included in where 10 participants in CIMT group and another 10 participants recruited in bimanual therapy(BT) group with age 2 to 12 years. The treatment dose was 1 hour, 3 days in a week. After 6 weeks follow up test has done. The outcome was measured by Modified Ashworth Scale (MAS), Pediatric Arm Function Test (PAFT) and Quality of Upper Extremity Skill Test (QUEST). The Wilcoxon signed rank and Mann Whitney U test were used to analyze the data. Results: The CIMT group improved statistically all the components of unimanual function (p< 0.05) whereas BT group 50% better in unimanual function. The bimanual function in CIMT improved 100% (p< 0.05), BT group improved 60%. Weight bearing and protective extension were upgraded in CIMT group (p< 0.05) but in BT group not found better outcome (p> 0.05). Conclusion: This study investigated that CIMT and bimanual therapy are effective intervention in children with hemiplegic cerebral palsy. But CIMT group showed better improvement in all the functions of upper extremity for hemiplegic CP.***

Keywords: Cerebral Palsy, Hemiplegic Cerebral Palsy, Constraint Induced Movement therapy, Bimanual therapy.

1. Introduction

Cerebral palsy (CP) is one of major cause of childhood physical disability that persists throughout whole life and affect 17 million people worldwide [1]. CP is a non-progressive brain lesion of posture and movement disorder in prenatal, perinatal, and postnatal period [2]. It is attributed to non-progressive disturbances in the developing fetal or infant brain. These disorders of cerebral palsy are often accompanied by disturbances of sensation, perception, cognition, communication and behavior by epilepsy and by secondary musculoskeletal problems [3].

The prevalence of CP is approximately 3 to 4 per 1000 live births in United Stated (US). Spastic CP is more common and it is estimated 61% to 76.9 % of all cases [4]. The epidemiological studies reported that males are affected of CP than females [5]. It is also estimated that the burden of CP is 5 to 10 times more common in low and middle-income countries [6]. In Bangladesh, it was found that the prevalence (estimated) of cerebral palsy is 3.7/1000 among sensory and motor impairments aged 0 to 18 years [7].

In hemiplegia, one side of the body is more impaired than the other; the upper limb is typically more affected than the lower limb, and the impairments compromise the child's ability to reach, grasp, release and manipulate objects [8]. Limited strength and coordination on one side of the body affect many aspects of the child's life, including play, self-care, and overall function in many daily activities, thus interfering with proper motor development on multiple levels [9].

The management of patients with cerebral palsy must be individualized based on the child's clinical presentation and requires a multidisciplinary (MDT) approach. Management of children with cerebral palsy is involved with an MDT approach from different medical health professionals [10]. The rehabilitation of cerebral palsy is always a challenging for professionals and different therapies are listed in literature which follows multiple theoretical framework. Physiotherapist plays a pivotal role in multidisciplinary team as a movement expert. Physiotherapy has a great role to support the children with cerebral palsy to maximize their functional independence and fitness, to minimize the impairments and to improve quality of life of this child as well as their family [11].

There are a number of treatments available for the management of hemiplegic CP. Constraint Induced Movement Therapy (CIMT) is a neurorehabilitation strategy used to improve the dysfunction of upper extremity for unilateral or hemiplegic CP. Edward Taub developed this technique. The aim is to promotes the neuroplasticity in brain through repetitive practice [8]. The unaffected upper limb needs to restraint by using slings, gloves or soft mitt for at least six hours. There are two principles of CIMT, one is restraint of unaffected limb and another is more therapeutic task with affected limb [12]. The task including shaping, grasping or releasing object, turn a knob and other functional

task like pour water in a glass. By using this task CIMT can improve functional activities in children with hemiplegic CP [13]. Another study also supported that to improve arm function CIMT is effective for hemiplegic child [14]. Other emerging protocol for the management of hemiplegic CP is bimanual training. The bimanual therapy is suitable for children with hemiplegic cerebral palsy. It is an interventional approach that aim to increase functional independency by using both hands and it is very important for both hands to complete a task. In this technique affected limb along with unaffected side also facilitate to attain a task [15]. In bimanual therapy, children with hemiplegic CP is facilitate with age appropriate gross motor and fine motor activities or function. The children are engaged in active learning approaches. In this approaches bilateral symmetrical and asymmetrical movements are practiced [16].

This research was intended to add in literature and contribute in reaching final conclusion about superiority of either intervention. After completing this study, the researcher emphasized the efficacy of CIMT and bimanual therapy and also determine which technique is more effective than other.The aim of the study was to find out the effectiveness of constraint induced movement therapy and bimanual therapy on motor function of upper extremity in children with hemiplegic cerebral palsy. Hypothesis statement: The null hypothesis (Ho) was "the effectiveness of CIMT and bimanual therapy are equally effective in children with hemiplegic CP". The alternative hypothesis (Ha) was the effectiveness of CIMT and bimanual therapy are differently effective in children with hemiplegic CP.

2. Methodology

Study design: This study was an experimental type of equivalence trial. Randomization and the comparison of both groups were utilized in this type of study. Each group has assigned at random as the group 1 or group 2.

Study area: The data has been collected from two setting of Centre for the Rehabilitation of the Paralyzed (CRP), Savar, Dhaka. One was the outpatient services of Pediatric unit, CRP, Savar, Dhaka and another was Special Education Needs Unit (SENU) of CRP, Savar, Dhaka.

Study population: Children with hemiplegic cerebral palsy were the study population for this study at CRP, Savar, Dhaka.

Sample size: The researcher has taken 20 participants for this study on the period of September 2017 to June 2018. Within this limited time, it was not possible to take a large number of samples for this study.

Inclusion criteria: The inclusion criteria were including: 1) participants aged 2 to 12 years, 2) the wrist extension was more than 10◦, 3) he ability to follow instruction of participants 4) parents of participants' willingness and 5) the patients who were able to take treatment 3 days in a week up to 6 weeks.

Exclusion criteria: The children were excluded who hadcurrent/uncontrolled/ untreated seizures**,** any type of surgery for reducing the muscle tightness**,** received botulinum toxin therapy, any history of fracture in upper extremity and hearing and visual impairments which may interfere in treatment or testing.

Sampling procedure
The samples were selected by Simple random sampling (SRS). By flipping a coin, it was decided. In coin head confirmed the CIMT group and tail indicated bimanual therapy group. Total 20 participants met the inclusion and exclusion criteria. All participants had an equal chance to be selected in two groups. Every participant was selected by coin flipping.In this way researcher had selected total 20 participants for this study where 10 participants were in CIMT group and 10 samples were in bimanual therapy group.

Data collection method
The researcher has recruited two data collectors for two groups. Before collecting data, appropriate training has given to them. They used structured questionnaire for collecting data from participants.

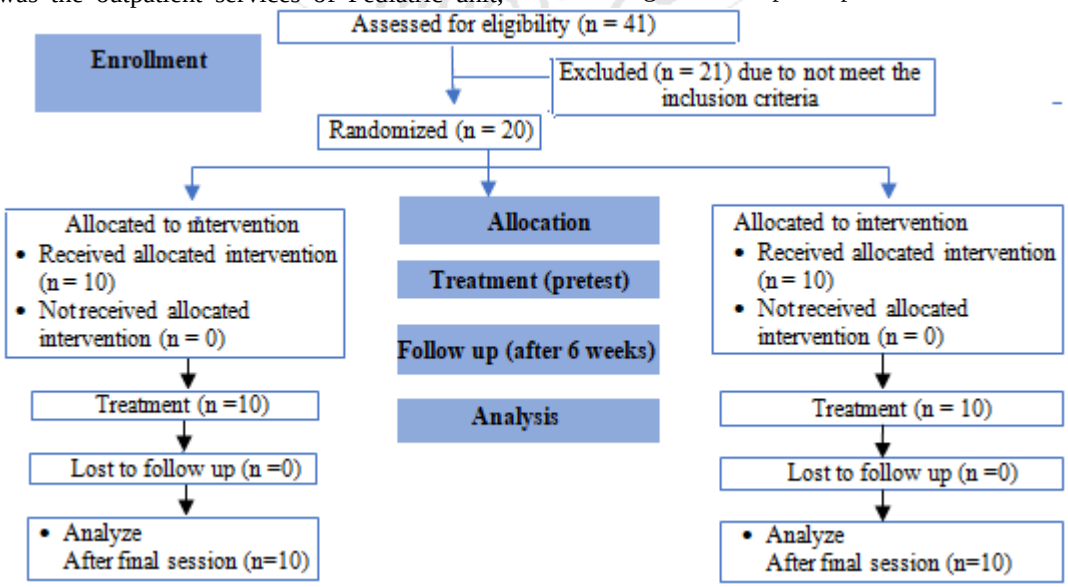

Figure 1: Consort Flow diagram

The full procedure is shown inconsort flow diagram. See figure 1.

Data collection instruments: The data collection materials were questionnaire, coin, pen, paper, ball and others were needed for collecting data.

Intervention: Participants were randomly divided in two groups where group A was used CIMT and group B was used bimanual therapy. The treatment dose was 1 hour, 3 days/week up to 6 weeks. Then after 6 weeks follow up testing was done. All treatment of groups was provided by graduate physiotherapists who are working as a clinical physiotherapist at Pediatric unit and SENU, CRP, Savar, Dhaka. In CIMT group (A), sound side was restrained by using arm sling (elbow bag). Rest interval was given according to child's need. For this group only, participant's carer was advised to use elbow bag at least 6 hours per day at home. In BT group, participants were facilitating to use both hands. The treatment components were including reaching in sitting and standing, grasp and release ball, build tower with large block, ring posting, weight bearing in sitting (in front, backward and sideways, ball throwing in a loop in sitting and standing, coordination practicing movement. Each component was practiced for at least 5 minutes to 10 minutes. At home mothers was advised this type of practice according to therapist advice.

Outcome measurement tools: The Manual Ability Function Classification System (MACS) was used as a functional classification to handle objects, Modified Ashworth Scale (MAS) to assess the severity of tonicity of upper limb, Quality of upper extremity skills test (QUEST) to evaluate the movement pattern and weight bearing in different position, Pediatric arm function test (PAFT) to assess the unilateral and bilateral function.

Data analysis: The researcher used Statistical Package for Social Science (SPSS) version 22 and others were used to calculate the descriptive statistics and non-parametric test.

Statistical test: Based on the type of data the researcher was utilized two statistical tests. For between group analysis researcher had done Mann- Whitney *U* test and for within group analysis used Wilcoxon Signed-rank test.

Level of significance: The significance level refers to the probability of rejecting a null hypothesis when it is true. This quantity ranges from zero (0.0) to one (1.0) and is typically denoted by the Greek letter alpha (α). Significance levels most commonly used in educational research are the 0.05 and 0.01 levels. Before collecting data, the significance level for this study has chosen and set to 5%. To assess the significance of the study p value was considered.

Ethical consideration: Ethical permission has been taken from the ethical committee of Institutional review board (IRB), CRP. Before starting data, researcher has taken permission from appropriate authority for data collection. The researcher also hardly maintained the confidentiality. Verbal and written consent has taken from each participant.

Informed Consent: The researcher used verbal and written consent from mothers. Informed consent is a crucial part for conducting any research. The researcher explained that participants are fully voluntary and they had full right to withdrawal from this study at any time and also assured that he maintained confidentiality. Where research involves children (under the age of 18) consent/permission has to be obtained from parent [17].

3. Results

Baseline Participant Characteristics

Table 1: The baseline characteristics of CIMT and BT group are given below:

Characteristics	CIMT (n=10)	Bimanual Therapy (n=10)
	Mean with SD	Mean, SD
Age in years	7.10±3.25	5.10±1.97
Gender		
Male	7 (70%)	7 (70%)
Female	3 (30%)	3 (30%)
Paretic arm		
Left	9 (90%)	9 (90%)
Right	1 (10%)	1 (10%)
Study setting		
PU	6 (60%)	8 (80%)
SENU	4 (40%)	2 (20%)

The table 1 has shown the baseline characteristics of CIMT and bimanual therapy (BT) group. The mean age and standard deviation in CIMT group was 7.10 and 3.25. In BT group mean age and standard deviation was 5.10 and 1.97. In total (n=20) participants 70% was in male where 30% was in female. In CIMT and bimanual group the male and female participants were in 70% and 30% also. In all participants 80% were in left sided hemiplegic CP and 20% in right sided hemiplegic CP. In CIMT group 90% participants were in left sided and only 10% in right sided hemiplegic CP. In Bimanual therapy group,70% in left sided and 30% in right sided hemiplegic CP. In all participants 70% (14) were from PU (Pediatric unit) and 30% (6) were from SENU (special education needs unit). In CIMT group 60% (6) participants were in PU and 40% (4) from SENU. In Bimanual group 80% (8) participants were from PU and only 20% (2) participants were from SENU.

Sociodemographic characteristics of participants

Living area of the participants: Majority of the participants 70% (14) lived in urban area and only 30% in rural area. 90% lived in urban area in CIMT group but in bimanual group 50% lived in rural and 50% in urban area.**Religion:** In total participants majority (90%) of the participants were in Muslim. Only 5% participants in Hindu and Christian.**Educational status of parents:** Among all participants 25% mother of children was graduated; 20% has completed SSC; 15% has completed primary, secondary and post-graduation but only 5% was illiterate and graduate. In father of children education, 25% has completed post-graduation; 20% has done graduate and SSC; 15% has completed HSC; 10% has completed secondary; 5% has done primary and 5% were illiterate.**MAS:** In all participants the flexor tone was found in shoulder, elbow

and in wrist muscle. In CIMT group, 70% of participants has muscle tone in 1+ (slight) and 30% has 1 (slight) in MAS at shoulder; 60% in 1+ (slight), 30% in 1 (slight) and 10% in 2 (considerable) at elbow; 70% of participants has 1 (slight) and only 30% in 1+ (slight) at wrist. In Bimanual group, 50% of participants has muscle tone in 1+ (slight); 30% has 1 (slight) and 20% in 2 (considerable) in MAS at shoulder; 40% in 1+ (slight) and 1 (slight) and 20% in 2 (considerable) at elbow; 40% of participants has 1 (slight), 1+ (slight) and only 20% in 2 (considerable) at wrist in MAS. **MACS:** In CIMT group, 50% of the participants quality of handle objects were in level III; 20% in level II and IV; 10% participants in level V in MACS. In bimanual group, 60% of the participants quality of handle objects were in level III, 30% in level IV and only 10% in level I in MACS.

Cooperativeness during treatment session: In CIMT group, 50% participants were somewhat cooperative during treatment session; 30% participants were very cooperative and 20% were not cooperative. In Bimanual therapy group, 50% participants were very cooperative, 40% were somewhat cooperative and only 10% participants were not cooperative in treatment session.

Within group analysis

The unimanual and bimanual function in CIMT group: In all the components of unimanual function there was increased every mean in posttest from pretest. All the components were improved significantly (p value <0.05). So, the result of unimanual function was statistically significant. All the components of bimanual function there was increased every mean in posttest from pretest. All the components were improved significantly (p value <0.05). So, the result of bimanual function was statistically significant. See table 2.

Table 2: Wilcoxon Signed-rank test in CIMT and BT (bimanual therapy) group of unimanual and bimanual function

Unimanual function		CIMT group	BT group
S/N	Variables	Sig. (2-tailed)	Sig. (2-tailed)
1	Reach above head	0.011*	0.035*
2	Reach at waist level	0.025*	0.011*
4	Reach across midline	0.011*	0.008*
5	Grasp ball	0.024*	0.053
6	Carry ball	0.023*	0.052
7	Release ball	0.008*	0.0059
8	Throw ball	0.009*	0.010*
Bimanual function			
1	Separate toys	0.023*	0.011*
2	Carry ball	0.038*	0.005*
3	Throw ball	0.011*	0.004*
4	Quadruped	0.046*	0.058
5	Crawling	0.025*	0.102
*=Significant			

The unimanual function and bimanual function in bimanual therapy group: In unimanual function, all the components in bimanual therapy group there was increased every mean in posttest from pretest. Among component of unimanual function; reach above head, reach at waist level, reach across midline and throw ball improved in posttest after getting treatment from bimanual therapy (p value < 0.05). So, the result was significant. But grasp ball, carry ball and release ball were not improved significantly (p value > 0.05). All the components of bimanual function there was increased every mean in posttest from pretest. The components; separate toy, carry ball and throw ball were improved significantly (p value < 0.05). But quadruped and crawling were not improved significantly (p value > 0.05). See table 2.

Between group analysis of unimanual and bimanual function (Mann Whitney *U* test)

Unimanual function in CIMT and BT group: In between group analysis, all the components of unimanual function in between CIMT and bimanual therapy group in posttest. Only one component: reach across midline improved in unimanual function among both groups statistically (p value < 0.05). Rest of the components were not improved significantly ((p value > 0.05). See table 3.

Table 3: PAFT questionnaire between CIMT and BT group (Mann Whitney U test)

Unimanual function		CIMT and BT	
S/N	**Variables**	**U**	**Sig. (2-tailed)**
1	Reach above head	49	0.966
2	Reach at waist level	38	0.348
3	Reach across midline	24	0.033*
4	Grasp ball	47	0.833
5	Carry ball	46	0.737
6	Release ball	45	0.709
7	Throw ball	49	0.968
Bimanual function			
1	Separate toys	32.5	0.155
2	Carry ball	24	0.025*
3	Throw ball	47	0.007*
4	Quadruped	25	0.028*
5	Crawling	32.5	0.125
***=Significant**			

Bimanual function in between two groups: The Mann Whitney *U* test has shown the comparison of bimanual function in between CIMT and bimanual group. Carry ball, throw ball and quadruped were improved significantly (p value < 0.05). For this instance, p value is less than 0.05. So, there was strong evidence to accept alternative hypothesis that mean the CIMT and bimanual therapy are effective in carry ball, throw ball and quadruped of bimanual function were improved statistically and significantly. For the separate toy and crawling of bimanual function were not improved significantly. So, in this circumstance, null hypothesis was accepted that indicted that the CIMT and bimanual therapy was equally effective in separate toy and crawling of bimanual function. See table 3.

Within group analysis of QUEST questionnaire in CIMT and BT group

Table 4: Wilcoxon Signed-rank test on weight bearing (QUEST questionnaire)

S/N	Variables	CIMT group	BT group
		Sig. (2-tailed)	Sig. (2-tailed)
1	Weight bearing in prone lying	0.914	0.118
2	Weight bearing in cross leg sitting	0.025*	0.435
3	Weight beating in 4-point kneeling	0.038*	0.273
4	Protective extension in backward	0.018*	0.131
5	Protective extension in sideward	0.047*	0.273
***=Significant**			

In CIMT group, all components were improved statistically (p value<0.05) except weight bearing in prone lying (p value>0.05). But in BT group, all components were not improved statistically (p value>0.05). See table 4.

Between group analysis of weight bearing

Table 5: QUEST between CIMT and BT group (Mann Whitney U test)

S/N	Variables	*U*score	Sig. (2-tailed)
1	Weight bearing in prone lying	47	0.810
2	Weight bearing in cross leg sitting	32	0.155
3	Weight beating in 4-point kneeling	48	0.871
4	Protective extension in backward	40.5	0.438
5	Protective extension in sideward	35.5	0.234

The table 5 showed that the all results was not statistically significant on weight bearing in prone lying, cross leg sitting, 4-point kneeling and the protective extension in backward and sideward between CIMT and BT group (p value >0.05).

Dissociative movement in CIMT and bimanual therapy group: Themean was increased from pretest in both group (CIMT and bimanual). But p value was more than 0.05 in each movement in CIMT and bimanual therapy group. So, this result indicated that there is strong evidence to accept the null hypothesis. Therefore, the result was not significant statistically.

The Mann Whitney *U* test on dissociative movement between CIMT and bimanual group: It showed that Mann Whitney U score of all the components of dissociative movement; shoulder flexion and elbow flexion with supination were 50, 40 and 30 respectively in where the tabulated value is 23 for n1=10 and n2=10. The p value of all the components were large or more than 0.05. So, this result was not statistically significant.

Within group analysis of muscle tone

Wilcoxon Rank test of the muscle tone in CIMT group: It showed that 2 participants had reduced muscle tonicity in CIMT group during posttest. No participants had higher reduction of the muscle tone after receiving CIMT in posttest. In addition, 8 participants had equal amount of muscle tone in pretest and posttest after getting CIMT. The p value is 0.157 which is more than 0.05. So, this result was not statistically significant.In bimanual group, it showed that 3 participants had reduced muscle tonicity in bimanual group during posttest. No participants had higher reduction of the muscle tone after receiving bimanual group in posttest. In addition, 7 participants had equal amount of muscle tone in pretest and posttest after getting bimanual therapy. The p value is 0.83 which is more than 0.05 that indicate the findings of the result was not significant.

Between group analysis of muscle tone: It is showed that the calculated value of U is 45 for the muscle tone in CIMT and bimanual group. The tabulated value of U is 23 in where n1 and n2 =10 in 5% (0.05) significance level. The calculated value was 45 in between two groups. Though the p value is more than 0.05 and also Mann Whitney U score is more than tabulated value so this result indicated that there is strong evidence to accept the null hypothesis. Therefore, the result was not significant.

4. Discussion

The aim of this study was to find out the effectiveness of constraint induced movement therapy and bimanual therapy on motor function of upper extremity in children with hemiplegic cerebral palsy.

In this present study, it was found that CIMT was statistically significant in unimanual and bimanual function for hemiplegic CP. Bimanual therapy group not improve significantly (p value >0.05) in unimanual, bimanual function and in upper extremity skills. In this present study researcher used restraint time was maximum 6 hours/day for CIMT group and used QUEST questionnaire. The researcher used elbow bag or sling to restraint the unaffected side. Now a days, physiotherapist use mitten, glove and sling or elbow bag more than casting. A systematic review also supported it. This review used 27 RCTs; only 3 studies used cast and rest of study used mitten, splint, glove, bandage and sling[18].

The dose of treatment was 1 hour, 3 days/week up to 6 weeksduring physiotherapy session and advised to mother for using the elbow bag for 6 hours per day in this current study. By using longer duration in 6 hours 5 days weekly for 4 weeks another study was conducted by a randomized controlled trial on 30 children. They found that CIMT is effective to improve upper limb function in children with unilateral CP. The outcome measures were PAFT, QUEST. The within group analysis showed significant result was found in unimanual and bimanual function (p value <0.05). But in between group analysis found there was no significant difference (p value >0.05) [19]. But in this present study, between group analysis showed that unimanual function (only reach across midline) and bimanual function (carry ball, through ball and quadruped) statistically significant result (p value <0.05).

A study was done in where one group received CIMT and another group used BIM. The aim of this study was to find out comparison the effectiveness of CIMT and bimanual therapy (BIM) on upper extremity motor function in children with hemiplegic cerebral palsy. This RCT randomly allocated 20 participants. After that 2 participants were dropped out and experimental group, n=9 and control group, n=9. In inclusion criteria age ranged was 1.5 to 12 years, active wrist extension, and fingers extension having 10 degrees. The dose of treatment was 6 hours, 6 days for 2

weeks. The QUEST (quality of the upper extremity skills test.) was outcome measure tool and CIMT effective significantly than BMT in grasping except in weight bearing (*p* value< 0.05) [20].

In this present study similarly CIMT group was more effective significantly than bimanual group. The outcome measures were also same. Another similar design study was compared the CIMT and bimanual intervention to promote hand function in children with hemiplegic CP. Total 42 participants divided in two groups; the CIMT group (n=21) and the BIM group (n=21). The dose of treatment was 6 hour per day for 2 weeks in both groups. Used outcome measurement tool Jebsen Taylor Test of Hand Function (JTTHF). It was concluded that both treatments showed similar effect but CIMT is effective to improve hand function by using Jobsen Tailor Hand Function test and Goal Attainment Scale BIM group showed better improvement. So, author investigated that CIMT is effective to improve hand function [16].

Another study was done on hand function in children with unilateral CP. This systematic review compared the effectiveness of CIMT with bimanual training in improving impaired arm function for hemiplegic CP. The seven RCTs were included in this review. Form result it is concluded that CIMT is effective in unilateral function comparing with bimanual treatment and for bimanual performance bimanual training is effective. In this review treatment duration of the included studies were not equal but therefore decided on treatment dose of CIMT is 6 hours per day, 3 sessions for 10 weeks. But in this present study, CIMT is effective in unimanual and bimanual both functions. The bimanual group was not statistically and significantly effective in bimanual as well as bimanual function while between group analysis. In within group analysis CIMT group improved all the components of unimanual and bimanual function (*p* value < 0.05). But for bimanual group few components (50%) were improved significantly (*p* value < 0.05) [21].

A systematic review was done on upper limb function in children with hemiplegic CP. From 597 studies finally 31 studies were included. In this review the experimental group has received CIMT and control group received no intervention or usual therapy or other intervention. Majority of studies used sling or gloves and used QUEST as outcome measurement tool. All included studies were 100% randomized and 97% done between group analyses so that it is realized that CIMT is more effective than other treatment in measuring upper extremity skills [22]. But the present study showed that between group analysis results were not statistically significant for QUEST.

During conducting this study there were some limitation. Firstly, the small sample size in this study is certainly a limitation. Secondly this study was conducted only within CRP. For this reason, this study cannot generalize for whole population of cerebral palsy. In addition, only participants were blinded during treatment session. Therapists were not blinded which could reduce or minimize the observer bias or experimenter bias or research bias during providing treatment.

5. Conclusion

This thesis has shown that CIMT and bimanual therapy is effective in improving motor function of upper extremity in children with hemiplegic cerebral palsy.

This study has found statistically that only CIMT is effective in unimanual, bimanual and some components of upper extremity skills. In other hand, bimanual therapy is no more effective in unimanual, bimanual and components of upper extremity skills. There was no changing in muscular tonicity in CIMT and bimanual therapy among children with hemiplegic cerebral palsy.

Future studies should consider the importance of the constraint induced movement therapy and bimanual therapy when implementing interventions in the population of children with CP with large sample size as well as more study area.

This study was provided the primary evidence on the effectiveness of constraint induced movement therapy and bimanual therapy in children with hemiplegic cerebral palsy. Further investigation in the context of CIMT and bimanual therapy for children with hemiplegic CP is needed. Future studies are needed with more study area so that results can generalized for all the population of hemiplegic CP. Future studies should use larger sample sizes.

6. Abbreviations

CP: Cerebral Palsy, CIMT: Constraint Induced Movement Therapy, BT: Bimanual Therapy, MAS: Modified Ashworth Scale, MACS: Manual Ability Classification System, PAFT: Paediatric Arm Function Test, QUEST: Quality of Upper Extremity Skill Test.

7. Acknowledgement

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8. Conflict of interest

The authors stated that they have no conflict of interest.

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