Cerebral Palsy - Advancements in UE Therapy

Technology-Enhanced Upper Limb Physical Rehabilitation in Hemiplegic Cerebral Palsy

Abstract

Cerebral palsy (CP) is the most common lifelong disability affecting motor development in children. Hemiplegic CP is the most common syndrome in children born at term. Numerous rehabilitation approaches have been reported in children with CP. Recent studies have shown that robot-assisted training can complement conventional therapies in children with cerebral palsy. In this study we present a case of an 18 year old girl with spastic hemiparesis as a form of cerebral palsy, who showed significant recovery after intensive technology-enhanced physical rehabilitation using Armeo spring system.

Keywords: Hemiplegic cerebral palsy; Upper limb rehabilitation; Armeo spring

Introduction

Cerebral palsy (CP) is a neurodevelopmental disorder characterized by movement and posture abnormalities. Incidence of CP in countries of the Western world is approximately 2-3 per 1,000 births. Children with CP usually show signs of muscle weakness, sensory deficits, as well as spasticity [1]. Spastic CP is classified in unilateral and bilateral forms [2]. A number of rehabilitation approaches have been reported in children with CP. Bobath concept is a form of conventional therapy, based on motor learning strategies [1]. Recent studies have shown that robot-assisted training can complement conventional therapies in children with cerebral palsy [2,3]. In this study we present a case of an 18 year old girl with spastic hemiparesis as a form of cerebral palsy, who showed remarkable recovery after intensive technology-enhanced physical rehabilitation using Armeo spring system (Figure 1).

Materials and Methods

An 18 year old girl with a diagnosis of a cerebral palsy with a right-sided spastic hemiparesis came to our clinic for rehabilitation treatment using Armeo Spring system. She was a prematurely born child and her previous medical history included Achill tendon operation at the age of three. Since her birth and before coming to our clinic she received standard physical therapy using Bobath treatment, administered by a physiotherapist, for 1 hour per day, 5 days a week. The locomotor system was assessed at the beginning and end of the treatment programme with Armeo Spring. Main outcome measurements included Fugl-Mayer (FM) score as a measure for motor assessment of the upper extremity, Functional Independence Measure (FIM) as a parameter for global functional evaluation and Modified Ashworth Scale (MAS) as a measure of muscle spasticity [4]. Training frequency was 5 times per week for 12 weeks. One session lasted 40 min.

Results

On her initial physical examination right shoulder abduction and anteflexion were terminally limited. Muscle strength in elbow flexors and extensors was 4/5. Right fist was held in wrist flexion, she could not actively perform right wrist extension and cold not completely clench her fist. Grasp was crude and release was slow, she could hold objects for manipulation by her left hand. She could not perform thumb opposition. MMT (manual muscle test) of right fist was 3/5. Right forearm pronation was in the normal range, but supination could only be initiated. Left leg muscle strength was 4/5. Muscle tone on right extremities was increased. Baseline FM score was 42, FIM 116 and MAS was 2.

After treatment with the arm weight support device hand function improved. Right shoulder abduction and anteflexion were in the normal range. Muscle strength in elbow flexors and extensors was 5/5. Right fist was held in wrist flexion, she could not actively perform right wrist extension, but there was an increase in muscle strength and range of movements. Grasp, release and opposition activities improved. MMT of right fist was 4/5. Right forearm pronation was in the normal range, and supination improved. There was some reduction in muscle spasticity. FM score increased significantly to 50, FIM increased to 120 and MAS decreased to 1+.

The results of treatment with Armeo Spring showed significant improvement measured in FM score and FIM comparing to treatment with conventional physical therapy by Bobath method. So far a number of rehabilitation approaches have been reported in children

Figure 1: Showing rehabilitation treatment with Armeo Spring system.

with CP such as anticonvulsants, bimanual training, botulinum toxin, bisphosphonates, casting, constraint-induced movement therapy, context-focused therapy, diazepam, fitness training, goal-directed training, hip surveillance, home programmes, occupational therapy after botulinum toxin, pressure care, selective dorsal rhizotomy, and robot assisted training [5]. The Bobath technique is the most common method of motor stimulation and it is used worldwide. It is designed to promote practice of task- specific, functional skills by active participation. Its aims are to inhibit spasticity and abnormal patterns of movement, improve postural alignment, and to facilitate normal automatic and voluntary movements [1]. Although it improves motor function, recent review study has shown that the results of treatment children with CP using Bobath therapy have limited effectiveness. The main disadvantages of Bobath therapy stated in this study are not significantly improving muscle contracture and tone, since it aims to reduce hyper-reflexia by repositioning the limb, thereby providing local effects, and not working on centrally driven spasticity long term [5]. A recent meta- analysis also showed weak to moderate effects of Bobath therapy on improving quality of upper limb movement and fine motor skills despite its common use in clinical practice [6].

Children often do not find this kind of therapy motivating, and do not achieve adequate training duration and intensity, which potentially leads to reduced therapy effects.

Armeo Spring is a system used for upper limb rehabilitation. It is an exoskeleton which provides gravity support for the affected upper limb by means of a spring mechanism and magnifies any residual active movement of the hemiparetic arm. As a seven degree of freedom orthosis with built-in position sensors it gives information about specific movement parameters (resistance, strength, range of motion and coordination), with a possibility of system sensitivity adjustment depending on the patient's condition. In its distal region it includes a grasp pressure sensitive handgrip which allows a graded performance of grasp and release exercises. This system enables participants to practice independent task-oriented and repetitive movements in a virtual three-dimensional learning environment, involving central neural pathways related to proprioceptive and visual feedback processing [2,4,7].

This kind of interactive approach is very motivating for patient and allows tasks to be executed repeatedly with higher intensity.

This is a relatively new technology, so far two studies have described favorable results in upper limb rehabilitation using Armeo Spring in children with CP [2,3], and further studies are required. Our study has also shown significant recovery in a relatively short time period using patient motivating and interesting intensive task- specific training.

In conclusion, our results showed that Armeo Spring system is a useful method for improving upper limb functionality. It is advisable to implement its use additionally to conventional therapy so that children with CP could achieve the best possible outcomes.

Effect of Manipulating Object Shape, Size and Weight Combined with Hand-Arm Bimanual Intensive Training (HABIT) in Improving Upper Extremity Function in Children with Hemiplegic Cerebral Palsy-A Randomized Controlled Trial

Abstract

Background: Hand Arm Bimanual Intensive Training (HABIT) has proven to improve upper extremity performance and co-ordination in children with hemiplegia. Children with unilateral spastic cerebral palsy display deficits in motor planning and execution that impact the timing and co-ordination of joint movements, orientation of the hand to object size, shape, weight and use, and calibration of fingertip forces. Bilateral impaired modulation of aperture, decreased bilateral ability to orient the hand prior to object contact based on forthcoming actions with the object was also reported.

Objective: To study the effect of Manipulating object shape, size and weight combined with Hand-arm bimanual intensive training(HABIT) in improving actual use of the more affected arm for completing activities commonly carried out in daily life, child's ability to handle objects and reducing spasticity in children with hemiplegic cerebral palsy.

Material and method: Thirty patients who fulfilled the inclusion criteria were randomly allocated into two groups. Group A-HABIT with Object Manipulation, Group B- HABIT without Object Manipulation with 15 patients in each group. All the patients were evaluated with Pediatric Motor Activity Log, Modified Ashworth Scale and Manual Ability Classification System at pre-and post-treatment level.

Results: There were significant decrease in spasticity MAS (p=0.001) & improvement in upper extremity function PMAL-R (p=0.001) & MACS (p=0.001) in both the groups post intervention. HABIT with object manipulation with different shape & size group had significant improvement on PMAL-R (p=0.002) & MACS (p=0.009) but no change in spasticity MAS (p=0.679) as compared to HABIT with object manipulation with similar shape & size group.

Conclusion: From finding of this study conclude that HABIT with Object Manipulation with different shape and size have positive effect in improving upper extremity function in children with hemiplegic cerebral palsy but not in spasticity reduction after 4 weeks of intervention.

Keywords: Cerebral palsy; Hand arm bimanual intensive training (HABIT); Manipulation; Object shape; Size; Weight

Introduction

Cerebral palsy is defined as an "umbrella term covering a group of non-progressive, but often changing, motor impairment syndromes secondary to lesions or anomalies of the brain arising in the early stages of its development" [1]. Cerebral palsy (CP) is the most common cause of physical disability in childhood, with an estimated incidence of 2.11/1000 live births [2,3].

The topographic classification of CP is monoplegia, hemiplegia, diplegia and quadriplegia; monoplegia and triplegia are relatively uncommon [4]. Hemiplegia accounts for 35% (1 in 1300) of these children and upper limb (UL) involvement is usually more pronounced than the lower limb. The resulting impairments to upper extremities may demonstrate abnormal muscle tone with posturing into wrist flexion, ulnar deviation, elbow flexion, and shoulder internal or external rotation in addition to reduced strength, as well as tactile and proprioceptive disturbances. All the previous impairments can result in abnormal development of hand skills and consequently affect functional independence and quality of life as well as skilled independent finger movement [5,6]. Length of the muscle plays an important role in the amount of muscle tension, so decrease in muscle length beyond resting level due to spasticity leads to decrease in the maximum force exerted by the muscles, which in turn affects grasping. Impairments of the involved upper extremity in children with hemiplegic CP may underlie some of the functional limitations that decrease their independence [7,8].

There is some evidence that the impaired hand function is not static during development, as the rate of development of the involved hand of children with CP largely parallels to that of typically developing children, so one key to rehabilitation is to alter the rate of development that may enable children with CP to more closely approximate the functional independence and social integration observed in typically developing children [9]. Consequently, as children with hemiplegia have impairments in bimanual coordination; an interventional approach to increase functional independence during activities of daily living by using both hands in cooperation in a form of bilateral hand-arm bimanual intensive therapy is needed [10-12].

HABIT is a form of functional training that takes advantage of the key ingredient of CIMT (intensive practice), but focuses on improving coordination of the two hands using structured task practice embedded in bimanual play and functional activities. It uses principles of motor learning (practice specificity, types of practice, feedback), 21 and principles of neuroplasticity (practice-induced brain changes arising from repetition, increasing movement complexity, motivation, and reward) [13-16].

Apart from the purely physical object constraints on the hand pose, there is also a functional correlation between object shapes and the manner in which they are grasped by a hand. The act of grasping is a skilled activity that involves motor planning and fine motor coordination to control multiple degrees of freedom available to the hand and fingers. Children with Unilateral Spastic Cerebral Palsy (USCP) display deficits in motor planning and execution that impact the timing and coordination of joint movements, orientation of the hand to object size and use, and calibration of fingertip forces. There are two important aspects to successful grasp-motor control and the sensorimotor experience. When motor control is impaired, the hand is used less often, limiting the sensorimotor experience [17-22].

Bilateral impaired modulation of aperture (distance between thumb and index finger) to object size, an indicator of hand-shaping was described in children with USCP. Decreased bilateral ability to orient the hand prior to object contact based on forthcoming actions with the object was also reported. Contoured objects require complex configurations of multiple digits for accurate grasp. Aperture alone does not capture the finger coordination patterns used for grasping because joint angles of each digit differ based on object shape [23-28].

Need of the study

Hand Arm Bimanual Intensive Training has proven to effective in improving upper extremity performance and co-ordination in children with hemiplegia [14]. Children with USCP display deficits in motor planning and execution that impact the timing and co-ordination of joint movements, orientation of the hand to object size, shape, weight and use, and calibration of fingertip forces. Bilateral impaired modulation of aperture (distance between thumb and index finger) to object size, an indicator of hand-shaping, was described in children with USCP. Decreased bilateral ability to orient the hand prior to object contact based on forthcoming actions with the object was also reported. So, the need arises to study the effectiveness of manipulating object size, shape and weight combined with hand arm bimanual intensive training in improving hand functions in children with USCP.

Aim of the study

The aim of this study is to find out Effect of manipulating object shape, size and weight combined with hand-arm bimanual intensive training in improving upper extremity function in children with USCP.

Objectives of study

To study the effect of HABIT combined with object manipulation in improving actual use of the more affected arm for completing activities commonly carried out in daily life in children with USCP.

To study the effect of HABIT combined with object manipulation on spasticity in children with USCP.

To study the effect of HABIT combined with object manipulation to see the child's ability to handle objects in children with USCP.

Materials and methodology

- Record or Data Collection Sheet.
- Consent Form.
- Pediatric Motor Activity Log-Revised
- Modified Ashworth Scale
- Manual Ability Classification System
- Objects with different shapes, size and weight
- Chair
- Stool

Methodology:

- Type of Study: Experimental study
- Study Design: Single Blinded Randomized Controlled trial.
- Study Setting: Neuroscience department of Physiotherapy OPD, MGM Hospital Aurangabad, Other hospitals and private clinics of Aurangabad.
- Sample Size: 30

Group A-HABIT with Object Manipulation (Different size, shape and weight)

Group B-HABIT with Object Manipulation (Same size, shape and weight).

- Type of sampling: Simple Random Sampling, Lottery method
- Duration of intervention: 4 weeks
- Duration of study: 1 year

Inclusion criteria:

- Children diagnosed as USCP.
- Age between 4-8 years.
- Both male and females.
- Hand spasticity ranged between 1 and 1+ grades according to the Modified Ashworth Scale
- Able to communicate
- Able to follow commands
- Ability to achieve minimal active grasp with the impaired hand.
- Sufficient co-operation and cognitive understanding to participate.

Exclusion Criteria:

- Children with moderate and severe spasticity

- Visual or auditory impairments
- Previous orthopedic surgery in the UL.
- Fixed upper limb deformities
- Botulinum Toxin injections in the UL within 6 months prior to study entry.
- Suffering from other diseases that interfere with training.
- Any change in spasmolytic medications expected during the study period

Outcome measures

Modified ashworth scale: Modified Ashworth Scale (MAS) is used to assess spasticity in muscles. The Ashworth scale produces a global assessment of the resistance to passive movement of an extremity, not just stretch-reflex hyperexcitability. Specifically, the Ashworth score is likely to be influenced by non-contractile soft tissue properties, by persistent muscle activity, by intrinsic joint stiffness, and by stretch reflex responses [29-31].

Pediatric motor activity log-revised: The PMAL-R is a structured interview intended to examine how often and how well a child uses his/her involved upper extremity (UE) in their natural environment outside the therapeutic setting. The PMAL-R Arm Use scale with the original 6-step structure exhibited high reliability, stability, accuracy, and responsiveness to change in children between 2 to 8 years with a wide range of severity of upper extremity hemiparesis due to CP [32,33].

Manual ability classification system: The Manual Ability Classification System (MACS) has been developed to classify how children with cerebral palsy (CP) use their hands when handling objects in daily activities. The classification is designed to reflect the child's typical manual performance, not the child's maximal capacity. It classifies the collaborative use of both hands together [34,35].

Procedure

Informed Consent: Before implementing the study, informed consent was taken from the parents of the children (Tables 1 and 2) [36,37].

Activity	Description
Dough activities	Roll large ball of dough between the two palms or roll two equal sizes of dough by both hands at the same time on the table
Ball activities	Throwing or catching different sized balls (start with large ones)
Cubes activities	Transferring cube from non-affected to the affected hand and towering cubes. Started with 3 cubes till 6 cubes (first tower with the uninvolved limb and then with the involved one)
Bottle and marbles activities	Put marbles into bottle. First the affected hand stabilized the bottle and the child performed the task with the no affected hand. Task difficulty was increased by using the non-affected hand in putting marbles
Stacking rings	Child held the rings starting with large one and stack with the non-affected hand and put rings on with the affected hand
Stringing beads	Stabilize the rope first with the affected hand and the less affected hand stringing beads. Task difficulty was increased as the non-affected hand holds the rope and the affected hand performs the task. First large beads and thick cord were used progressing to small beads and thin cord
Manipulation activities	* Alternate banging and clapping movements
	* Fastening clothing, button and unbutton buttons, open and close zip
	* Twist the lid of the jar
	* Twist and press a lock and its key
	* Cutting of paper by scissors

Table 1: Description of hand arm bilateral intensive therapy (HABIT).

1	The children with USCP performed 10 lifts with their hands with the object's weight adjusted to 200 g, 400 g, 600 g, 800 g and 1000 g respectively.
2	6 differently shaped objects (rectangular, circular, square, cylindrical, concave and Convex) were used.
3	Object size: small (3 cm height-6 cm wide), medium (4 cm-8 cm) or large (5 cm-10 cm).

Table 2: Object manipulation with different shape, size and weight.

Step 1: Children diagnosed as USCP were recruited from various physiotherapy centers, hospitals.

Step 2: Children fulfilling inclusion criteria were included in the study and randomly allocated to either group.

Step 3: Procedure was explained to the child and parents & written informed consent taken.

Step 4: Children were made to sit on a chair of comfortable height and a table was given in front to place the objects.

Step 5: In Group A HABIT with Object Manipulation with different size, shape and weight were given, which included repetitive functional bimanual reach-to-grasp tasks using objects varying in size, weight, and shape along with conventional physiotherapy program.

Step 6: In the beginning, therapist assisted the child in doing the activities. Progression was done on the basis of successful achievement of repetition with the previous object size, shape and weight.

Step 7: Each exercise was given 10 repetition per set. Intervention was given for 6 days a week for total 4 weeks. Treatment duration of one session was approximately 40 minutes.

Step 8: In Group B HABIT combined with object manipulation was given with single object size, shape and weight for 40 minutes, 6 days in a week for 4 weeks.

Step 9: 6 Square shaped objects, 6 objects 800 g weight each and 6 Medium size objects (4 cm and 8 cm) were given for Group B.

Step 10: Conventional physiotherapy treatments based on ADL were given to both the groups which included: Passive, Active assistive & Active ROM Exercises, Weight bearing & Weight shifting exercises. These exercises prevent complications of immobilization and improve ADL skill at the earliest. This helps in preventing contractures and development of abnormal postures [38,39].

Step 11: At the end of 4 weeks, effect of intervention was seen by Pediatric motor activity log-revised (PMAL-R), Modified Ashworth Scale (MAS), and Manual Abilities Classification System (MACS).

An approval from MGM's Institute of Health Sciences ethical committee was taken before starting the study. The Protocol number of Ethical Committee Approval was MGM-ECRHS/2015/221.

Data Analysis

Data were analyzed and tabulated with SPSS version 22 (Statistical Package for Social Sciences) for windows and Microsoft Office Excel-2007. Mean, standard Deviation, Degree of freedom, confidence level, P value and significance were calculated to express the results. Parametric statistical tests Paired & Unpaired t test were applied in the study.

Levene's Test for has been used Equality of Variances for two groups: Unpaired' test has been done for Inter Group Comparison of Pediatric motor activity log-revised (PMAL-R), Modified Ashworth Scale (MAS), Manual Abilities Classification System (MACS) in between Experimental and Control Group for Pre-and Post-intervention level.

Paired' test has been done for Intra-Group Comparison for Pediatric motor activity log-revised (PMAL-R), Modified Ashworth Scale (MAS), Manual Abilities Classification System (MACS) Experimental and Control Group at Pre-and Post-intervention level.

Results

46 children were assessed for eligibility. Out of which 5 children were excluded because they refused to participate in study, 7 children unable to fulfill the inclusion criteria. Total 34 children were randomized and divided in to two groups. Group A and Group B. There was 4 drop out from study, 2 children from each group. Total 30 children, 15 in each group completed the whole intervention and included for data analysis. Total 19 Males and 11 Females were participated in the study (Table 3).

		Group A	Group B	Df	T Value	P Value
Age		6.67 ± 1.66	6.56 ± 1.87	28	0.164	0.51
Gender	Male	10	9			
	Female	5	6			
Causes of CP	Prenatal	8	9			
	Postnatal	7	6			
Dominant side	Right	10	12			
	Left	5	3			
Hemiplegic side	Right	7	5			
	Left	8	10			
MAS		1.60 ± 0.50	1.40 ± 0.50	28	1.08	1
PMAL-R		1.46 ± 0.51	1.53 ± 0.51	28	-0.354	1
MACS		2.66 ± 0.48	2.40 ± 0.50	28	1.46	0.478
P<0.05* shows a statistically significant result.						

Table 3: Mean and SD of age and pre-intervention level comparison between group a and group b for pmal-r, mas and macs.

When comparison of mean and SD between the group A and B was done for pre-values of MAS (p=1.0), PMAL-R (p=1.0), and (p=0.47) the result was not significant (Figures 1-3, Table 4).

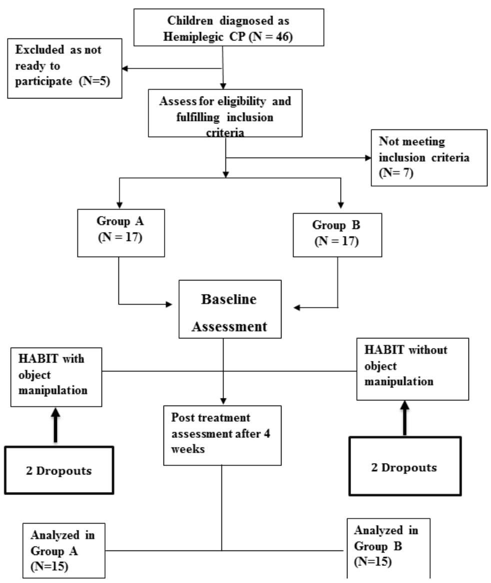


Figure 1: Showing diagnosed children.

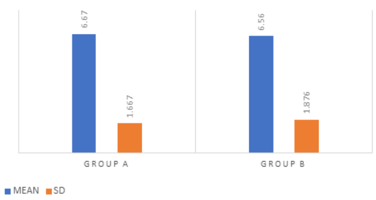


Figure 2: Mean and SD of ages of children of the groups.

Group A	Pre	Post	Df	T Value	P Value
MAS	1.60 ± 0.50	0.733 ± 0.45	14	6.5	0.001
PMAL-R	1.46 ± 0.51	3.46 ± 0.63	14	-14.49	0.001
MACS	2.66 ± 0.48	1.33 ± 0.48	14	8.36	0.001
P<0.05* shows a statistically significant result.					

Table 4: Pre-and post-intervention comparison of group a for mas, pmal-r, and macs.

When comparison of mean and SD within the Group, A was done for pre-and post-values of MAS, PMAL-R, and MACS, the MAS value decreased and PMAL-R and MACS values increased (Table 5).

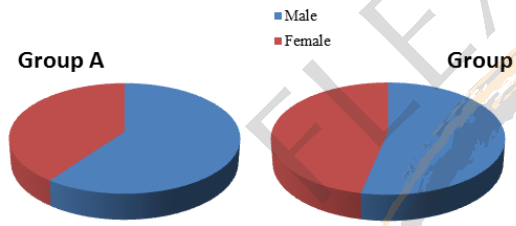


Figure 3: Gender wise Distribution of population.

Group B	Pre	Post	Df	T value	P value
MAS	1.40 ± 0.50	0.80 ± 0.41	14	4.58	0.001
PMAL-R	1.53 ± 0.51	2.40 ± 0.48	14	-4.51	0.001
MACS	2.40 ± 0.50	1.80 ± 0.41	14	3.15	0.007
P<0.05* shows a statistically significant result.					

Table 5: Pre-and post-intervention comparison of group b for mas, pmal-r, and macs.

When pre-and post-values comparison was done for group B for MAS, PMAL-R, and MACS, MAS value decreased and PMAL-R and MACS values increased post intervention (Figure 4, Table 6).

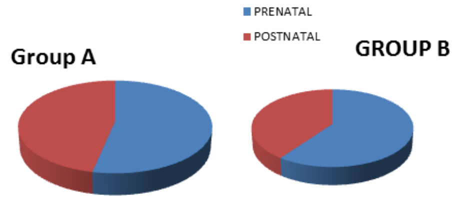


Figure 4: Pre-natal and post-natal history wise distribution.

	Group A	Group B	Df	T Value	P Value
MAS	0.73 ± 0.45	0.80 ± 0.41	28	-0.41	0.679
PMAL-R	3.46 ± 0.63	2.46 ± 0.91	28	3.46	0.002
MACS	1.33 ± 0.48	1.80 ± 0.41	28	-2.82	0.009
P<0.05* shows a statistically significant result.					

Table 6: Post intervention level comparison between group a and group b for mas, pmal-r, and macs.

When post intervention level comparison between group A and B was done for post values of MAS, PMAL-R & MACS, MAS value was similar in both the groups whereas PMAL-R & MACS values was higher in Group A (Figures 5 and 6).

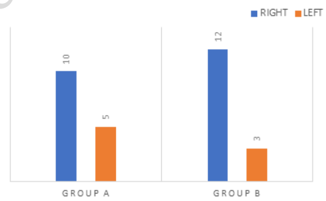


Figure 5: Dominant sidewise distribution.

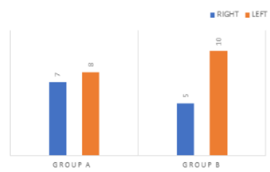


Figure 6: Hemiplegic sidewise distribution.

Discussion

The result of study demonstrates that Hand Arm Bimanual Intensive Training is feasible for USCP, providing preliminary support to improve outcomes on actual use of affected arm, spasticity and handling objects in daily life. These improvements are consistent with previous studies that have shown benefits from the Hand Arm Bimanual Intensive Training (HABIT) [40,41].

A study done by Hung et al. [12] to find out effect of intensive bimanual training on coordination of the hands in children with congenital hemiplegia. Results suggest that bimanual training improves the spatial-temporal control of the two hands [42].

Serrien et al. [43] did study to find out weather Damage to the parietal lobe impairs bimanual coordination, concluded that brain damage associated with hemiplegia often includes areas known to be involved in bimanual coordination such as the supplementary motor area and the parietal lobe [43,44].

A Meta-analysis conducted on Bilateral movement training and stroke motor recovery progress which is also in favor of finding of this study as bimanual training was included along with object manipulation [45].

Lewis et al. didn't find real additional beneficial effect of bilateral practice on 6 post stroke patients. They find, when a positive influence of the bilateral intervention was suggested, it tended to be in tasks with lower performance scores for participants with moderate motor deficits. They also note that the task that had the largest involvement of proximal musculature also had the more reliable facilitatory effects. Given the contribution of bilateral descending pathways to proximal musculature, movements requiring activation of these proximal muscles may profit most from bilateral training protocols [46].

Hand-arm bimanual intensive therapy (HABIT), which simultaneously activates the same neural networks in either hemisphere which decreases the inter-hemispheric inhibition. This is because right and left hemispheres have symmetrical organization for hand control in the motor cortexes which are both activated during bimanual hand training that in turn leads to improvement in inter-hemispheric communication and ipsilateral motor cortex activation of the affected hemisphere. [47] During symmetrical bimanual movements, there is a coupling of movements of the two extremities with one or both of the movements being affected [19-21]. Motor learning principles would suggest that improvement in use of two hands together maximized by repetitive practice of bimanual goal directed tasks [22]. Early bimanual use of both hands is thought to be important for the development of the assisting hand, as the development of motor control is modeled on effective use of the dominant hand [23]. This can be one of the reasons the motor activity log has improved in this study.

On the contrary Jackson and colleagues [48] have argued that a sensorimotor mechanism, based upon proprioceptive coding of limb position and motion, exists to maintain interlimb co-ordination during movement execution. Although untested to date, this would suggest that intact proprioception is a critical prerequisite for beneficial effects with bimanual training protocols [48,49]. Mudie and Matyas [50] reported that, bilateral simultaneous movement promotes inter hemispheric disinhibition which is likely to allow reorganization by sharing of normal movement commands from the undamaged hemisphere. Disinhibition may also encourage recruitment of undamaged neurons to construct new task-relevant neural networks [50].

Related to findings of this study, Wiesendanger and Serrien [43] have concluded that Lesion location alone, therefore, may not be very useful in predicting who will or will not benefit from bimanual training protocols. Given the distributed nature of bimanual coordination, we can also conclude that the majority of our patients will manifest deficits in bimanual coordination, and, therefore, bimanual training activities should be at least a part of any comprehensive rehabilitation program [51].

MAS is used to see change in spasticity. Significant change was found in spasticity in both the groups at post intervention level. Bilateral simultaneous movement promotes inter hemispheric disinhibition which is likely to allow reorganization by sharing of normal movement commands from the undamaged hemisphere. Disinhibition may also encourage recruitment of undamaged neurons to construct new task-relevant neural networks [46,50]. This can be the reason due to which spasticity has reduced in our subjects. In addition, subjects were also asked to repeat the activities which is also one of the factors that has contributed in reduction of spasticity in this study.

Another finding of this study suggest that, there was no difference in spasticity reduction in both the group at post intervention level but HABIT with Object Manipulation with different size & shape was more effective as compared to Habit with Object manipulation with similar shape & Size. Although upper extremity function improvements were seen in both the groups but greater amount of improvement in upper limb function especially handling objects in daily activities was noted in group A (Hand-Arm Bimanual Intensive Training with different object size, shape and weight manipulation). Therefore, the alternate hypothesis is accepted.

Wolff et al. [52] conducted a study on Differentiation of hand posture to object shape in children with USCP. They concluded in their study that Children with USCP were able to differentiate their hand posture to objects of different shapes, but demonstrated deficits in the timing and magnitude of hand-shaping that were isolated to the affected side. This is in agreement with our findings in which handling objects of different shapes and sizes showed improvement in the handling of objects [52].

On the contrary, study done by Ronnqvist and Rosblad [53] concluded that the less affected hand showed delayed aperture formation during reach and the more affected hand demonstrated no anticipatory shaping at all, while another cohort of children achieved peak aperture at 90% of reach in both hands, compared to 50% in TD children [53].

Another possible explanation of this finding is that when object size and shape varied, while holding an object between the index and thumb, the individual has to generate a shear force in order to overcome the weight of the object and prevent the object from slipping from the fingertips. The magnitude of the shear force is related to the friction coefficient of the object and the magnitude of the pinch force. Therefore, grip force can be modulated as a function of the friction between the fingertips and the object surface and, also, the weight of the object. Slippery and heavier objects will generally require larger grip forces. Usually the grip force is slightly larger than the minimal grip force mechanically required to hold the object, providing a security margin allowing small perturbations to be corrected without dropping the object. Many studies have demonstrated the precise coordination between the grip force and the shear force during the manipulation of an object [54].

The studies done by Flanagan et al. [55] concluded that the motor system adapts to the size-weight illusion within a few lifts, whereas it takes many days of training to overcome the distorted perception of weight. These studies illustrate the fast adaptation of the motor system for lifting but slow adaptation of the perceptual system for the judgment of object size and weight [55].

Bert Steenbergen et al. [56] conducted study on Fingertip force control during bimanual object lifting in hemiplegic cerebral palsy. It was observed that there was a close synchrony of both hands when the task was performed with both hands, despite large differences in duration between both hands when they performed separately, bimanual tasks may have the potential to facilitate force control of the affected hand. the present results suggest a form of asymmetrical mutual adaptation, primarily, but not exclusively, established by the less-affected hand. Importantly, these findings indicate that bimanual movements may help the affected hand to produce more 'regular', or fine, force control. When a property of an object (e.g. weight or texture) changes unexpectedly, the motor system adapts quickly to adjust the forces used to lift the object [56].

No Children in either group reported adverse effects/discomfort with intervention. It is recommended that further research can be conducted by increasing the duration of the study and the sample size. Since the protocol is beneficial in improving motor function, it can be added along with conventional physiotherapy to gain additional effects.

Limitations

- Small sample size and short Study duration i.e., only for 4 weeks.
- The study analyzed only the short-term benefits.
- No follow up after 4 weeks intervention.

Future scope of study

- Follow up can be done to see effect of bimanual training with object manipulation in future clinical trial, on a larger sample size with longer duration.
- Similar Research can be performed on other type of cerebral palsy patients, stroke patients, Parkinson's disease, Multiple Sclerosis patients.

Conclusion

From finding of this study conclude that HABIT with Object Manipulation with different shape and size have positive effect in improving upper extremity function in children with hemiplegic cerebral palsy but not in spasticity reduction after 4 weeks of intervention.

Effects of Modified Constrained Induced Movement Therapy to Improve the Upper Limb Functional Activities and Gross Manual Dexterity on Hemiparetic Cerebral Palsy Children

Abstract

Background: cerebral palsy is a neuro developmental disorder. It has various types. Hemiparetic cerebral palsy is a type in which the children have limitations in capacity to use the impaired upper limb on daily life activities. This study aims to find out the effects of modified Constraint induced Movement therapy (modified CIMT) to improve the upper limb functional activities and gross manual dexterity among the children with hemiparetic cerebral palsy.

Methods: 10 children with hemiparetic cerebral palsy were undergone to modified CIMT. Interventions lasted for 4weeks, 4hrs/day, Peadiatric Motor Activity Log(PMAL) to assess the children's upper limb functional activities and box and block to assess gross manual dexterity were used before and after intervention.

Results: The results showed significant improvements on functional measures of PMAL and gross manual dexterity of box and block.

Conclusion: modified CIMT is an effective therapy to improve the upper limb functional activities and gross manual dexterity on the children with hemiparetic cerebral palsy.

Keywords: Cerebral palsy; Modified constraint induced movement therapy; Paediatric motor activity log; Box and block; Gross manual dexterity

Introduction

Cerebral palsy (CP) is a neuro developmental disorder caused by non-progressive lesion in the immature brain. It may occur before, during or after birth. The early central nervous system damage results in physical disabilities and sensory impairments. The prevalence of cp is approximately 2- 2.5 per 1000 births, with hemiplegia accounting for approximately 25% of all new cases worldwide. CP is mainly classified to the spastic, ataxic, dystonic, and choreoathetosis. Hemiplegia is a type of spastic cerebral palsy [1-3].

Impaired hand function is a major debilitating factor for the performance of activities of daily living in hemiplegic cerebral palsy. The impairment of the hand is often the result of damage to the motor cortex and cortico spinal pathways responsible for the fine motor control of the fingers and hand [4]. Recent evidence suggests that children with CP may improve motor performance if provided with sufficient opportunities to practice. One treatment approach that is becoming increasingly popular is constraint-induced movement therapy (CIMT). Constraint Induced Movement therapy is a new technique used in physical rehabilitation to treat individuals with decreased upper extremity functions. It involves constraining the unaffected limb, along with intense therapy, in order to force the use of the affected side with the intent to improve motor function. It is a task driven treatment that combines principles of behavioral psychology and motor learning [5-9].

CIMT is a therapy for children with hemiplegia which involves encouraging use of the affected arm while restricting use of the unaffected arm. The types of restraints have included slings, mitts, splints, and casts. The restraint may be applied from a few hours up to twenty-four hours of a child's day. During the period of constraint the child may receive therapy to facilitate practice using the affected arm from as little as one hour to as much as six hours daily per week. The practice may be formal and structured involving behavioral shaping strategies or be less formal. Modified CIMT is vary in the frequency, duration, and type of constraint in treatment regimen [6-10].

Methods

Study Design

An experimental study was conducted to find out the effects of modified CIMT on children with hemiparetic Cerebral Palsy.

Sample

10 subjects were selected after giving due consideration to inclusion and exclusion criteria.

Sampling method

Random sampling technique was used to select the samples.

Inclusion Criteria

- Diagnosis of hemiplegic cerebral palsy

- Both gender with children aged 8 to 12 years
- Modified Ashworth scale (MAS) grade>1but<3
- cognitively competent and able to understand and follow the instructions
- wrist at 20° flexion and fingers at 10° flexion

Exclusion Criteria

- Visual problems
- Prior upper limb surgery
- uncontrollable seizures
- Botulinum toxin A injection in the upper limb within 6 month prior to study

Outcome measures

Paediatric Motor Activity Log

- How often scale
- How well scale

Box and block

Paediatric Motor Activity Log (PMAL) is the Motor Activity Log scale which is developed for children with unilateral CP and includes a mixture of unimanual and bimanual activities. The child's caregiver was interviewed to evaluate how well and how often the child used their affected upper extremity based on 22 functional activities of young children. The PMAL was scored on a scale from 0-5 [4,7,8].

Using the Box and Block Test, gross manual dexterity was determined as the maximum number of blocks transported from one compartment of a box to another in 1 min [11-14].

Procedure

10 hemi paretic cerebral palsy children were selected. Consent was obtained for the participation of the child and the child's parent prior to enrolment. Pre evaluation was done by Pediatric Motor Activity Log (PMAL) and box and block. Interventions were delivered in children for 4 hours per day for 4 weeks. Post intervention readings were taken after 4 weeks on the same outcome parameters.

The intervention involves restraint of the noninvolved extremity using a sling and engaging the child in uni manual activities with the involved extremity 4 hours a day for 4 weeks. The sling is strapped to the child's trunk. The sling is worn continuously throughout this time period except when a break is requested. The tasks include board games, card games, manipulative games, puzzles, arts and craft, functional task, and gross motor activities. The games like magnetic board for placing the alphabets or shapes, grasping and releasing the objects in various sizes and shapes, transporting the objects, turning and arranging the pictures, tooth picks or clay to create design or objects, place or remove the stickers, tissue paper scrunching- crumble up then throw them, turn a knob, push a button, pour water in a glass etc. Repetitive practice was given in play way method in group setting. As the child improves, the task is made more challenging.

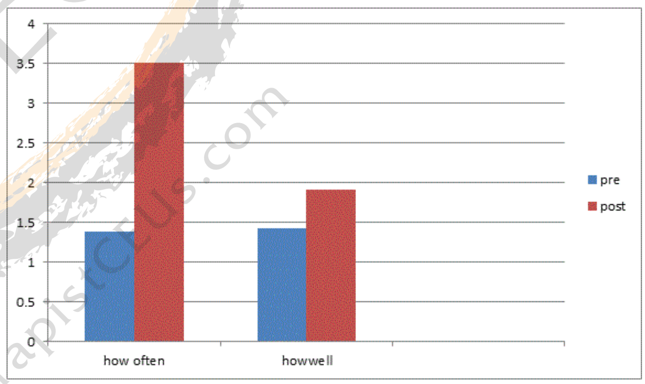
Data analysis and Results

The aim of the study was to find out the effectiveness of modified Constraint induced movement therapy to improve the upper limb functional activities and gross manual dexterity on children with hemiparetic cerebral palsy.

Table 1 displays the PMAL values for both how well and how often scale of pre and post treatment .The results showed significant differences in improvement on PMAL in both how well (7.85) and how often scale (12.91) which is greater than table value (2.262).so the significant improvement in PMAL score in modified CIMT.

Variables		Mcimt		Calculated t value	Table value
		Mean	SD±		
PMAL How well	PRE	1.42	0.14	7.85	2.262
	POST	1.91	0.27		
PMAL How often	PRE	1.39	0.28	12.91	
	POST	3.51	0.51		

Table 1: Comparison between pre and post in PMAL

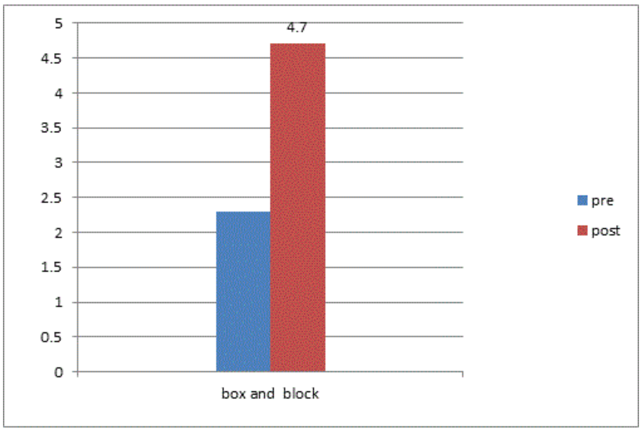


Graph 1: Comparison between pre and post Mean of PMAL

variables		Mcimt		Calculated value	Table value
		Mean	SD+		2.262
Box and Block	PRE	2.3	0.94	10.85	
	POST	4.7	1.15		

Table 2: Comparison between pre and post in Box and Block Test

Table 2 displays the box and block values for pre and post treatment of modified CIMT. The result showed significant differences in improvement on box and block (10.85) which is greater than table value (2.262). So the significant improvement in box and block score in modified CIMT.



Graph 2: Comparison between pre and post Mean of Box and Blocks

Discussion

Present study was done to find out the effectiveness of modified CIMT to improve upper limb function activities and gross manual dexterity in children with hemiparetic cerebral palsy.

The modified CIMT had been proven to be effective in improving functional activities and gross manual dexterity of upper limb .The result came in agreement with Eliassion et al. [5] Rostamie et al. [7], Gorden and Charles [8] and Choudhary et al. [9]. Improving functions maybe, using the affected hand more in functional activities and also it has long been believed that the brains of children are felt to have more capability than adults for cortical reorganization and it has been suggested that children with asymmetric upper extremity motor control may also benefit from constraint therapy. Modified CIMT is effective in improving motor recovery in patients with hemiplegia because of increased size and shifting of cortical area neural firing after CIMT [4,13].

Conclusion

The modified CIMT is a effective treatment method to improve the upper limb functional activities and gross manual dexterity among the children with hemiparetic cerebral palsy.

Effect of Repetitive Transcranial Magnetic Stimulation on Hand Function of Spastic Cerebral Palsy Children

Abstract

Repetitive Transcranial magnetic stimulation (rTMS) is emerging as a new investigation as well as treatment tool for various neurological and psychiatric diseases. Recent studies showed its application as treatment tool in movement disorders, where rTMS stimulation on primary motor cortex alters physiological patterns of motor threshold; motor evoked potential and cortical plasticity which induces motor activity. Recent studies on rTMS combined with rehabilitation therapy demonstrated functional improvement in motor activities of spastic cerebral palsy (sCP) children. Thus, this study was designed to evaluate the effect of rTMS on hand function of sCP patients.

Forty-five children diagnosed as sCP participated in this study after written consent from their parents or guardians. They were divided into three groups- control (CG) and interventional group (IG-A and IG-B). Participants in CG were provided only physical therapy (PT) of 30 minutes duration daily for 20 days and those in IG were administered rTMS frequency of 5Hz (IG-A) and 10Hz (IG-B) for 15 minutes consisting of 1500 pulses daily for 20 days; followed by PT as given to CG. Quality of upper extremity skill test (QUEST) scoring was used for evaluating the improvement in hand function of sCP patients. The pre (before starting any therapy) versus post (after completion of 20 sessions) mean QUEST score between different groups were statistically significant ($p<0.01$) and the mean change was 0.61, 2.46 and 2.87 in CG, IG-A and IG-B respectively.

However, encouraging functional improvement in hand function was observed in diplegic patients in the age group of 2-6 years employing 5Hz frequency and higher frequency (10Hz) induced better activity in hemiplegic and quadriplegic patient of older age groups (7-16 years).

Keywords: Cerebral palsy; Physical therapy; Quality of upper extremity skill test (QUEST); Transcranial magnetic stimulation

Introduction

Ever since the introduction of repetitive Transcranial magnetic stimulation (rTMS) in 1989, several studies demonstrated rTMS as an investigational as well as a treatment tool for a variety of neurological and psychiatric disorders [1]. rTMS is a noninvasive brain stimulation technique that repeatedly stimulates cerebral cortex by a train of magnetic pulses. The stimulation modulates cortical excitability producing physiological changes in motor threshold; motor evoked potential and cortical plasticity [2]. These physiological changes can induce motor activity and helps in the treatment of movement disorders.

The application of rTMS in movement disorders was thoroughly reviewed by Kamble et al., where diseases such as Parkinson's and Huntington's disease, dystonia, progressive supranuclear palsy, etc., were discussed [3]. Additionally, recent publications reported positive effect of rTMS in cerebral palsy [4] demonstrating improved motor activity [5,6] along with reduction in muscle tightness [7].

Cerebral Palsy (CP) is a neurodevelopmental disorder that affects a developing child. CP occurs due to brain damage occurring in the fetal period or infancy which results in motor or sensory nerve damage leading to inability to perform activities of daily living [8]. CP presents itself in different forms - ataxic, spastic and dyskinetic; among which spastic CP is most common. Spastic cerebral palsy is a neuromuscular impairment that limits the movement and posture of the body due to increased tonic stretch reflex or exaggerated tendon reflex in the muscles [9]. These patients are not able to perform coordinated motor activities of upper and lower extremities.

Besides having difficulty in performing hand function such as grasping, lifting and weight bearing. In order to restore this motor disorder, diverse therapeutic approaches [10] are being employed, commonly known are task oriented training [11] and physical therapy [12]. These physical approaches helps in functional organization by repeatedly training on activity tasks associated with daily living based on motor learning and promotes controlled movements that are actually used when performing functional tasks [13]. Thus, in this study, we aimed to evaluate the effect of rTMS on hand function of spastic CP children combined with physical training (PT) exercises.

Materials and Methods

Participants

Forty-five participants diagnosed as spastic CP by consultant physician and pediatric neurologists participated in this study after written consent from their parents or guardians. These participants were equally divided into three groups namely, control group (CG), interventional group A (IG-A) and interventional group B (IG-B) matching age, CP type and age group. The demographic characteristic of participants is given in Table 1. Only participants that satisfied our inclusion criteria were selected from the out-patient department of UDAAN- for the differently abled, Delhi a non-profit organization that pioneered the rehabilitation of CP children using various interventions. The inclusion criteria followed was willingness to participate; age group between 2 to 16 years; muscle tightness mild to moderate, cognitive deficiency nil to moderate, limited hand function-grasping or weight bearing, no metallic implants, no uncontrolled seizures or congenital diseases. Data of some spastic CP children (3 in RG and 2 each in IG-A and IG-B) that showed near to normal hand function were not included for any analysis.

Variables	CG	IG-A	IG-B
Age ± SD (Years)	8.59 ± 4.81	8.33 ± 4.33	7.24 ± 5.01
Height ± SD (cm)	107.00 ± 24.80	114.71 ± 26.93	118.17 ± 15.99
Weight + SD (kg)	21.58 ± 15.62	27.14 ± 10.50	25.67 ± 13.85
Sex			
Male : Female	7 : 5	8 : 5	9 : 4
CP type			
Hemiplegic	4	3	3
Diplegic	5	7	6
Quadriplegic	3	3	4
Age group			
2-6 years	4	5	5
7-11 years	4	6	5
12-16 years	4	2	3

Table 1: Demographic characteristic of participants.

Stimulation device

TMS device used in this study delivered repetitive trains of magnetic pulses using Neuro-MS/D Variant-2 therapeutic (Neurosoft, Russia) with angulated figure of eight shaped coil (AFEC-02-100-C). The device had two channel Neuro-EMG–MS digital system for determining the motor threshold. The eight-shaped coil generated magnetic field of up to 4 Tesla at the center of the coil that when placed on the skull penetrates the cranium and enters into the soft tissue of the brain which stimulates the motor neurons. In this study, the coil was placed on the primary motor cortex which is known to be the motor pathway signaling center of the brain.

Assessment tool

The assessment tool used in this study was quality of upper extremity skill test (QUEST) which is a specially developed tool to overcome the limitation of measures of hand function in children with motor disabilities [14]. QUEST scoring is universally used to evaluate the functions of upper extremity that demands fine motor skills [15,16]. QUEST comprises of descriptive and impairment based measures which is designed to evaluate the hand function in spastic CP.

QUEST evaluates 36 items of upper extremity in four domains, namely, A- dissociated movements, B- grasping, C- protective extension and D- weight bearing. In order to calculate QUEST score, total values of each domain are added and averaged, then converted to percentage which was used for analysis.

Research design

The selection of participants and design of study protocol was performed only after approval from the institutional ethics committee for human samples or participants (IECHSP) of the host institution. Immediately after selection of participants, pre assessment of QUEST was performed on all participants of different groups namely, CG, IG-A and IG-B. Participants of CG were provided only PT for 30 minutes daily for 20 days (5 days per week for 4 weeks) whereas children in IG-A was administered rTMS of 5Hz frequency and those in IG-B with 10Hz comprising of 1500 pulses (50 pulses per train with total 30 trains having inter-train delay of 20 seconds) for 15 minutes daily for 20 days.

The rTMS session of both the groups were followed by PT of 30 minutes as provided to participants in RG. After completion of 20 sessions of different therapies administered to different groups, post-assessment of QUEST was performed. Both PT and rTMS sessions were administered by trained professionals and the assessment was done by a trained physiotherapist who was kept blinded to the research protocols used in the study.

Statistical analysis

The pre and post QUEST scores for each of the three groups were analyzed with a paired-sample *t*-test to determine statistical significance. The variance and covariance analyses were also performed. The mean and median QUEST scores were used to evaluate the percentage of functional gain that was induced by different therapies in different groups. Moreover, the percent change in QUEST scores were used to determine improvement in different spastic CP types and age groups. All statistical analysis was performed using SPSS 20.0 (Armonk, NY, IBM Corp., USA) and Microsoft Excel 2010. The *p*-value of less that 0.01 was considered statistically significant.

Results

The paired *t*-test between the pre and post QUEST scores in control (only physical therapy) group (CG) revealed significant differences ($t = -3.368$, $df = 11$, $p = 0.006$, confidence interval [CI] −1.0003 to −0.2097) with mean change of 0.61%. The *t*-test between pre-post assessments of QUEST scores in interventional (rTMS+PT) groups was also significant. In IG-A, t = −4.036, df = 12, p=0.002, CI -3.789 to −1.133 and in IG-B, t = −3.768, df = 12, p=0.003, CI −4.439 to −1.186. The mean change score was 2.46% in IG-A and 2.82% in IG-B. The QUEST scores between different groups are represented in Table 2.

Groups	Min		Max		Median		Mean ± SD	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
CG	39.76	40.97	88.75	90.23	63.84	64.68	62.79 ± 15.40	63.40 ± 15.42
IG-A	50.93	50.93	98.21	100	76.44	82.93	75.61 ± 15.89	78.07 ± 16.24
IG-B	49.29	51.61	91.67	98.15	80.22	81.71	74.28 ± 15.22	77.10 ± 14.87

Table 2: Descriptive statistics of control and interventional groups.

The improvement (mean change) in different groups was 0.61, 2.46 and 2.82 percent in CG, IG-A and IG-B respectively (Figure 1). This clearly demonstrated positive effect of rTMS over PT. But it was observed that mean change in both the interventional groups differed slightly; IG-B with 10Hz rTMS frequency revealed better improvement than IG-A (5Hz). However, considering the change in the median score (Figure 2), 5Hz seemed better that 10Hz frequency. This lead to ambiguity in the interpretation of result, thus in order to overcome this ambiguity, percentage functional gain according to CP type and age group was analyzed.

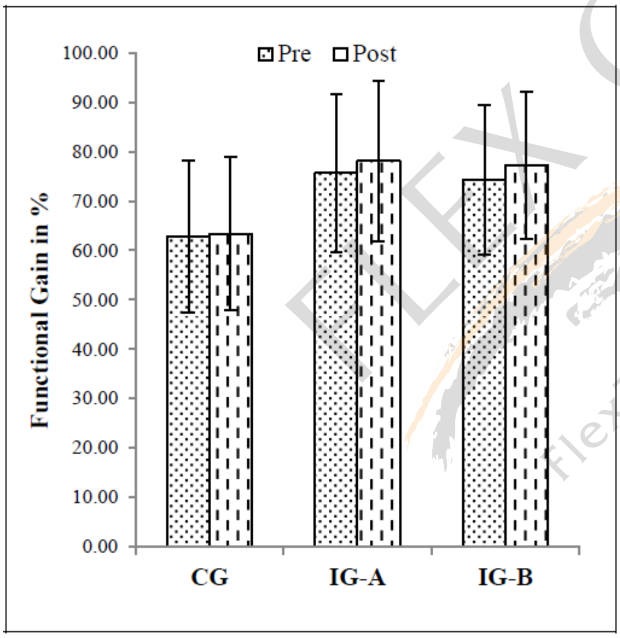


Figure 1: Functional improvement percentage in range of functional gain in QUEST score between QUEST scores between different groups.

The mean change between different spastic CP types (hemiplegic, diplegic and quadriplegic) in various groups showed minimal improvement by only PT (CG) compared to rTMS therapy group (IG-A and IG-B). Between IG-A and IG-B, 10Hz frequency showed appreciable functional gain in hand function in hemiplegic (4.04%) and quadriplegic (3.87%) patients as compared to diplegic (2.31%) patients. On the contrary, 5Hz rTMS frequency was more beneficial in diplegic (2.31%) patients compared to hemiplegics or quadriplegics in the same group (Figure 3).

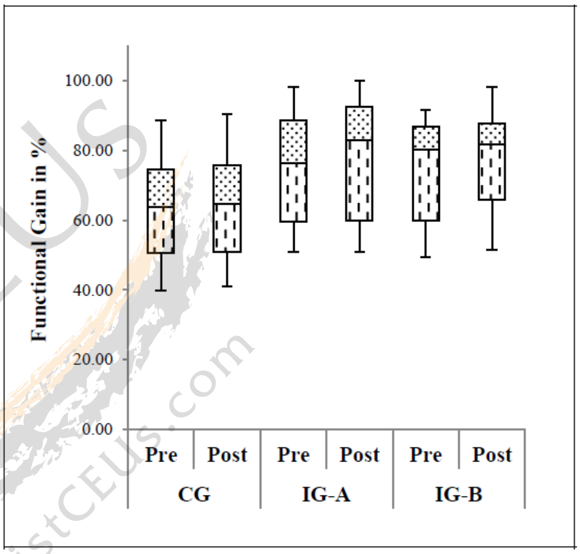


Figure 2: Box-plot showing change in median.

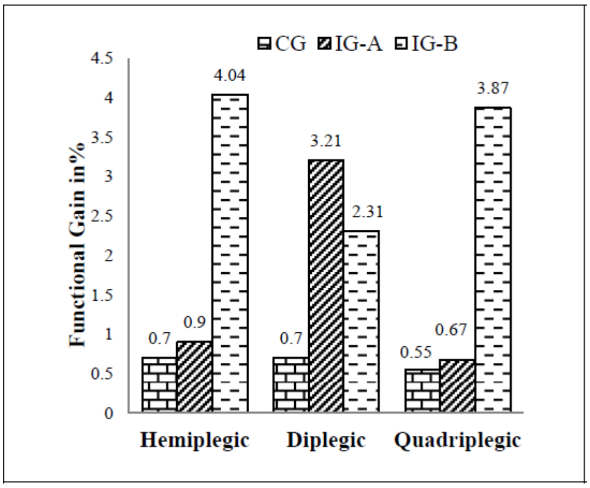


Figure 3: Improvement percentage between different spastic CP types following different therapy regime.

Comparing the effect of different therapies between different age groups, it was observed that combined rTMS and PT (IG) group demonstrated better functional hand activity compared to only PT

(CG). rTMS frequency of 10Hz induced better improvement (4.14%) in older children (12-16 y) compared to lower age group (2-11 y) children but 5Hz frequency was more beneficial (3.7%) in younger children (2-6 y) compared to older spastic CP patients (Figure 4).

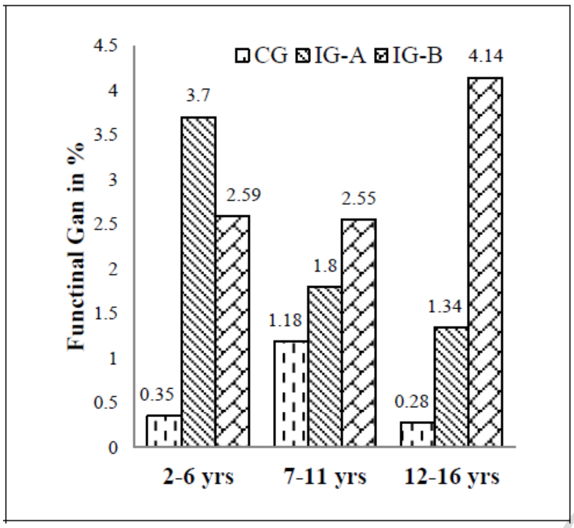


Figure 4: Improvement percentage between different age groups following different therapy regime.

The result demonstrated that though rTMS induces appreciable functional gain in hand function when compared to the traditionally employed physical training, lower frequency (5Hz) lead to better improvement in diplegic CP patients that are in the age group of 2-6 years and higher frequency (10Hz) induced better functional improvement in hemiplegic and quadriplegic patients of older age group in limited number of sessions.

Discussion and Conclusion

The interventions employed in the restoration of functional abilities in CP patients to make them perform activities of daily living are diverse and emerging. This diversity in interventions existed since there is no specific diagnostic protocol, nor is there a clear singular etiology and pathology for CP. Now-a-days rehabilitation of these patients is performed employing technology such as robotics, virtual reality and brain stimulations [17]. All these interventions are known to induce neural plasticity which traditional approaches fail to meet. rTMS too, induces brain plasticity [18] and produces lasting changes in brain function with potential therapeutic effects [19,20]. Studies on spinal cord injury (SCI), multiple sclerosis and stroke patients provide good evidence to show the effectiveness of rTMS combined with rehabilitation therapy on motor function [21-23]. Similarly, our findings in this study demonstrated that high frequency rTMS is beneficial in spastic CP cases to enhance their functional hand activity; but the effect of rTMS frequency differed accordingly between different CP types and age group of patients.

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