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Evaluating The Efficacy Of Hand-Arm Bimanual Intensive Therapy (Habit) For Reducing Spasticity In Pediatric Patients With Spastic Cerebral Palsy

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Abstract: **BACKGROUND AND PURPOSE:** To evaluate the efficacy of hand arm bimanual intensive therapy for reducing spasticity in pediatric patients with spastic cerebral palsy. **METHODOLOGY:** 10 patients with spastic cerebral palsy were taken in the study and given treatment. Non-randomized study before and after comparison without control. Out come measures are Peabody developmental motor scale and modified Ashworth scale. **RESULTS:** the results in the study revealed that hand arm bimanual intensive therapy (HAIBT) shows significant reduction of spasticity in cerebral palsy children. Where as that proves p values is <0.0001 by using PDMS modified Ashworth scale. **CONCLUSION:** In this study patients with spastic cerebral palsy showed improvement in fine motor function after using the hand arm bimanual intensive therapy (HABIT) intervention. As patients are advised to perform task-oriented activities like grasping, holding, removing pegs, fine motor skills were improved. The study was for 6weeks spasticity showed to be reduced with improved grip. Using Modified Ashworth scale spasticity was checked and PDMS is used to check fine motor function.

KEYWORDS: upper extremity rehabilitation, cerebral palsy, bimanual training, hand, posture, motor skill learning, intensive training, neurorehabilitation, gait, dose, children.

Introduction: Cerebral palsy (CP) refers to non-progressive disease with single or multiple lesions in the cerebral cortex, resulting in motor and some degree of sensory abnormality, as well as other associated disabilities. It occurs as a result of maternal factors or events at the time of labor and delivery (congenital cerebral palsy), or a variety of factors in early developing years (antenatal cerebral palsy). ([1])

Cerebral palsy is a group of permanent, irreversible posture and movement disorders, which leads to limitation of activities which is due to non-progressive problems that aroused in the immature fetal brain. The motion disorders sometimes associated with defects in sensory system are awareness, thinking, speech, language, behavior, and musculoskeletal problems. (1)

The prevalence of this disorder ranges from 2 to 2.5 per thousand children, being the most prevailing neuro-developmental disorder in children. Overall, the total rate of CP is relatively stable, yet the contribution of prematurity and its complication to the prevalence of this syndrome are steadily increasing due to improvements in obstetric and neonatal care. CP is more common among boys than among girls.([8])

The incidence of cerebral palsy has increased over years with the in success of medical intervention in keeping premature and low birth babies alive. (7)

HISTORY: The first person to identify cerebral palsy was the English surgeon William John Little (1810-1894). He stated that children with the condition have an injured nervous system that results in spasticity. Using the term 'Spastic cerebral palsy' his work was well regarded and the condition which is known today as cerebral palsy was called Little's Disease. Sir William Osler wrote the book on cerebral palsy. The book entitled "Cerebral palsies on children .

Hand arm bimanual intensive therapy (HABIT) is a part of physiotherapy used to treat fine motor disabilities in children with spastic cerebral palsy, it is a group of exercises, which include repetitive functional bimanual reach tasks using objects varying size, weight, and shape.

Cerebral palsy is a non-progressive neuromotor disorder of cerebral origin. ([2]) Cerebral palsy is commonly used term for group of conditions characterized by motor dysfunction due to non- progressive brain damage to developing brain.(3)
Cerebral palsy is a group of neurological disorders that appear in infancy or childhood and permanently affect body movement and muscle contraction. It is caused by damage to the brain or anomalies inside developing brain that disrupts brain ability to control and maintain posture and balance. The term cerebrum refers to brain and palsy refers to the loss of motor function.(4)

Cerebral palsy is a disorder of movement and posture that appear during early childhood. It is caused by non-progressive damage to brain before, or during, or shortly after birth. It is a not a single disease, but a name given for wide variety of static neuromotor impairment syndromes occurring secondary to lesion in developing brain.

ANATOMY OF BRAIN:

The brain is a component of central nervous system. It consists of three parts: the forebrain (telencephalon and diencephalon), the midbrain (mesencephalon), the hindbrain (metencephalon and myelencephalon).

The telencephalon (cerebrum), becomes the large cerebral hemispheres. The surface of these consists of elevations (gyri) and depressions (sulci) and the hemispheres are partially separated by deep longitudinal fissure. The diencephalon, which consists of the thalamus, hypothalamus, and other related structures. ([5]) The mesencephalon (midbrain), connects hind brain and fore brain. The metencephalon, which gives rise to the cerebellum and the pons. The myelencephalon (medulla oblongata), the caudal most part of the brain stem, ends at the foramen magnum. (5)

The brain is composed of three main structural divisions: The cerebrum. The brain stem, and the cerebellum. At the base of the brain is the brain stem, which extends from the upper cervical spinal cord to the diencephalon of the cerebrum. The brain stem is divided into the medulla, the pons, and the brain stem. Posterior to the brain stem lies the cerebellum. (6)

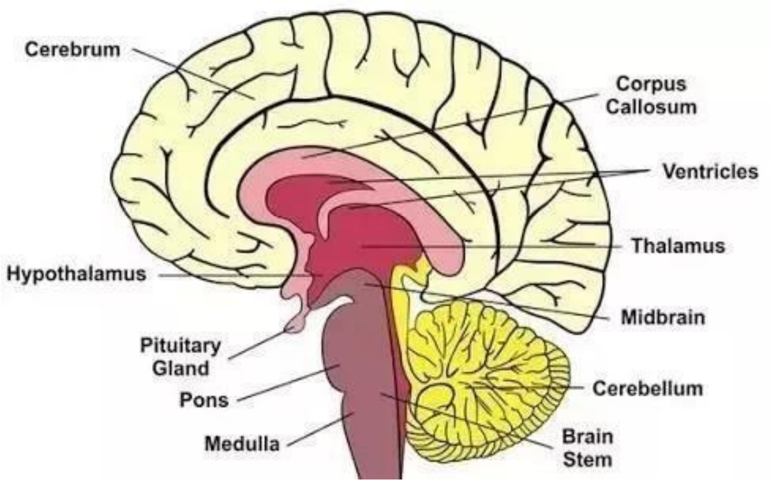

FIG-1: BRAIN AND IT'S PARTS

CEREBRUM: The cerebrum is the largest part of the brain. It is also called as pallium. It is divided into right and left hemispheres. The two hemispheres are connected to each other across the median plane of corpus callosum. The corpus callosum is the collection of white matter fibers that joins these hemispheres.

Each of these cerebral hemispheres is further divided into four lobes: the frontal lobe, the parietal lobe, the temporal lobe, the occipital lobe.([6])

The frontal lobe is distinguished from parietal lobe posteriorly by the central sulcus. The frontal lobe and parietal lobes are divided inferiorly from the temporal lobe by the lateral sulcus. Parieto-occipital sulcus between the parietal and occipital lobe. Callosomarginal fissure is between temporal lobe and limbic area.(6)

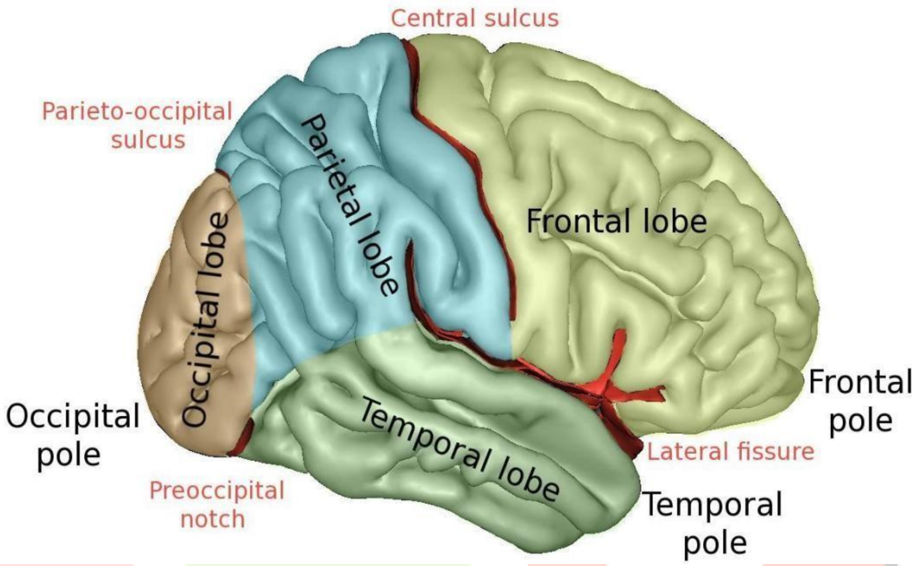

FIG-2: CEREBRUM

BRAIN STEM: It is divided into midbrain, pons, medulla oblongata.

MIDBRAIN: The midbrain is also termed as the mesencephalon, is the superior most aspect of brain stem. It connects third ventricle with fourth ventricle. ([6])

Ventrally, the mid brain appears as two bundles that diverge rostrally as the cerebral peduncles. Between the cerebral peduncles, the third cranial nerve (oculomotor) can be seen exiting. The fourth cranial nerve (trochlear) exits dorsally and is unique in this regard. It then courses anteriorly against the cerebral peduncles.

The posterior aspect of mid brain has two pairs with characteristic protrusions, the superior, and inferior colliculi. The superior colliculi are involved in mediating the Vestibulo-ocular reflex, whereas the inferior colliculi are involved in sound localization.(6)

MEDULLA OBLONGATA: The medulla oblongata is the most caudal part of the brain stem between the pons superiorly and spinal cord inferiorly. Ventrally, the pyramids and pyramidal decussation is visualized just below the pons. These are the descending corticospinal tracts. ([6])

Just lateral to the pyramids, the rootlets of the hypoglossal nerve can be seen as they exit the brain stem. Laterally to the rootlets of hypoglossal nerve is the inferior olive nucleus. Dorsolateral to the inferior olive, the rootlets of ninth and tenth cranial nerves (glossopharyngeal and Vagus) exit.

Dorsally, two pairs of nuclei are visible, which are the gracile tubercles medially and the cuneate tubercles just lateral to those. These represent the nuclei where sensory information from the dorsal columns is relayed onto thalamic projection neurons.

Just superior to these protrusions is the floor of fourth ventricle, which bears several characteristic impressions. The vagal trigone is the dorsal nucleus of Vagus nerve (cranial nerve x), which is just below the hypoglossal trigone.(6)

PONS: Superior to the medulla lies the pons, the ventral surface of which has characteristic band of horizontal fibers. These fibers are the pontocerebellar fibers that are in turn projections from the corticopontine fibers. These fibers cross to enter the contralateral middle cerebellar peduncle and thus enter the cerebellum.

On either side of the midline, there are bulges that are produced by the descending corticospinal tracts. At the pontomedullary junction, the sixth cranial nerve (abducens) can be seen exiting the brain stem. Laterally, but anterior to the middle cerebellar peduncle, the seventh and eight cranial nerves (facial and vestibulocochlear) can be seen exiting.(6)

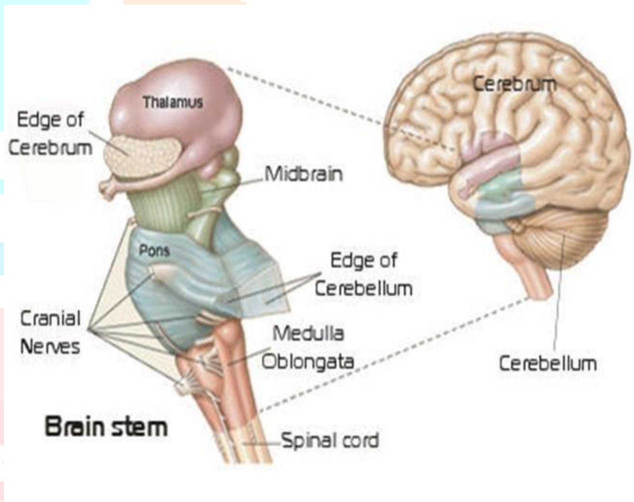

FIG -3: BRAIN STEM

CEREBELLUM: The cerebellum occupies the posterior fossa, dorsally to the pons and medulla.

It is involved primarily in modulating motor control to enable precisely coordinated movements. Similar to the cerebrum. Which has gyri and sulci, the cerebellum has finer folia and fissures that increase the surface area.(6)

The cerebellum consists of two hemispheres, connected by a midline structure called vermis. In contrast to the neocortex of the cerebrum, the cerebellar cortex has three layers: the molecular, Purkinje, and granular.

There are four deep cerebellar nuclei: the fastigial, emboliform, and dentate nuclei, in sequence from medial to lateral. The afferent and efferent pathways to and from the cerebellum exist within the three cerebellar peduncles. (6)

The etiology of cerebral palsy (CP) is very diverse and multifactorial. The causes are congenital, genetic, inflammatory, infectious, anoxic, traumatic and metabolic. The injury to the developing brain may be prenatal, natal, or postnatal. ([9])

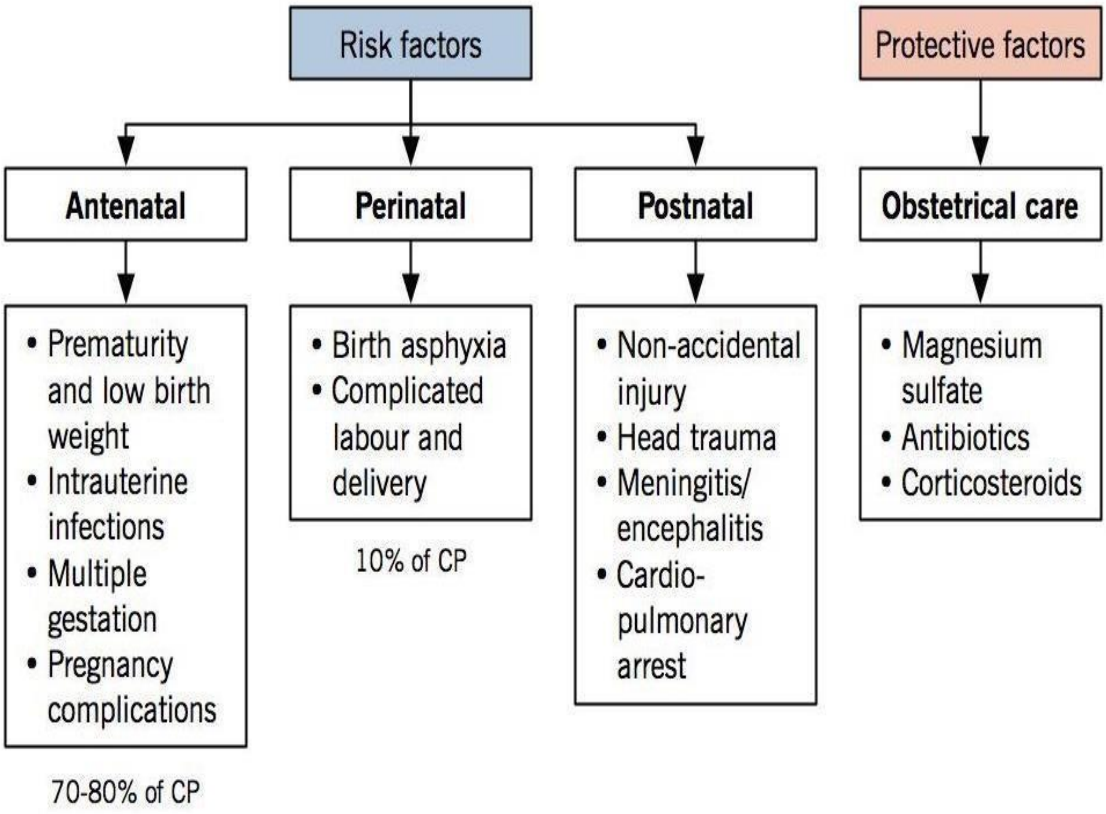

FIG – 4 RISK FACTORS FOR DEVELOPMENT OF CEREBRAL PALSY

The premature neonatal brain is susceptible to two main pathologies: Intraventricular Hemorrhage (IVH), and periventricular Leukomalacia (PVL). Although both pathologies increase the risk of Cerebral palsy.

Leukomalacia describes white matter in the periventricular region that is underdeveloped or damaged (leukomalacia). Both Intraventricular region and periventricular leukomalacia causes cerebral palsy because the corticospinal tracts composed of descending motor axons, courses through periventricular region.(12)

IVH describes bleeding from the subependymal matrix into the ventricles of the brain. The blood vessels around the ventricles develop late in the third trimester, thus preterm infants have underdeveloped periventricular blood vessels, predisposing them to risk of IVH. The risk of CP increases with severity of IVH.

Cellular factors such as cytokines, reactive oxygen species and excitotoxicity target the promyelinating oligodendrocytes, interfering with myelination of white matter. Together these factors give rise to under development of white matter in the periventricular area is known as Periventricular Leukomalacia.(12)
The symptoms of cerebral palsy vary from extent of damage and ranges from mild to severe.([13]) An infant with cerebral palsy have muscular and movement problems, including poor muscle tone.

Symptoms of cerebral palsy Overdeveloped or underdeveloped muscles, leading to stiff of floppy movements, Poor coordination and balance, Involuntary, slow writhing movement or athetosis.([14]) Stiff muscles that contract abnormally, known as spastic paralysis, Crawling in an unusual way, Lying down in awkward positions.[(14)], Delay in reaching motor skill
milestones, such as rolling over, sitting up alone or crawling, Delay in speech development and difficulty speaking, Ataxia or a lack of muscle contraction and exaggerated reflexes.([13]), Tremors or involuntary movements, Excessive drooling and problems with swallowing, Difficulty walking. [13]) Weakness in one or

more arm or leg, Walking on toes, a crouched gait or a scissored gait.([4]) Delay in reaching motor skill mild stones, Difficulty with precise movements such as writhing or buttoning a shirt. ([4])

Other symptoms of cerebral palsy Vision and hearing problems, learning disorders.([15]) ,

Decreased muscle strength, Pain in joints that is often caused by tight muscles or poor posture, Seizures.(15)

Common neurological conditions in people with cerebral palsy include Epilepsy, Intellectual disorders, attention deficit hyperactivity disorders (ADHD), Behavioral problems.([15]) Sensory impairments/pain. Symptoms might appear as early as 2 months of age. Parents usually notice delayed milestones as their child is not able to hold his or her head up, roll, crawl, sit, stand and walk.(15)

AIM OF THE STUDY

The aim of this study is to determine the effect of hand arm bimanual intensive therapy on improving fine motor function in children with spastic cerebral palsy.

OBJECTIVES OF THE STUDY

The objective of the study is reducing spasticity, improving motor function, improving in arm movement, quality of life.

METHODOLOGY

This study followed a non-randomized before-and-after design without a control group and included ten patients diagnosed with spastic cerebral palsy who presented with bilateral hand dysfunction. Participants were selected through a random sampling method from Moon Walk Physiotherapy Clinic. Each child met the inclusion criteria of being between 1 to 5 years of age, able to maintain an independent sitting position, and having upper extremity spasticity graded between 1 and 2 on the Modified Ashworth Scale. Children with upper limb contractures, infections, tumors, uncontrolled epilepsy, visual problems, mental retardation, coordination disturbances, or other pathological conditions such as chickenpox, jaundice, influenza, or spina bifida were excluded. The intervention consisted of 40-minute treatment sessions administered five days per week for a period of six weeks. Materials used in the study included colored charts, sketch pens, data collection sheets, a ball, and the Peabody Developmental Motor Scale–2 (PDMS-2) kit along with toys that facilitated bimanual activities such as clay, card games, video games, and arts and craft materials. Outcome measures included the PDMS-2, which assessed gross and fine motor skills and helped identify deficits, track progress, and compare performance with age-matched peers, and the Modified Ashworth Scale, which provided a measure of spasticity based on resistance to passive movement. All procedures were carried out as per standardized PDMS-2 and MAS assessment guidelines.

PROCEDURE

Before implementing the study, initial assessment and informed consent will be taken. Subjects who fulfill the inclusion criteria will be assigned based on convenient random sampling. Pretreatment evaluation will be done before starting the treatment. Post treatment evaluation will be done immediately after the treatment.
Step l: Children diagnosed with spastic bilateral hand dysfunction.
Step2: Children fulfilling the inclusion criteria were included in the study and randomly allocated.
Step3: Protocol was explained and written informed consent taken.
Step4: Children were made to sit on a chair of comfortable height and table was given in front to place the objects.
Step5: Object manipulation with different size, shape, and weight were given.

Step6: Therapist assist the child in doing activities. Progression was done on repetition with previous object size, shape.
Step7: Each exercise is given 10 repetitions per set. Intervention was given for 5 days a week for 6 weeks. Treatment duration of one session is 40 min.

Step8: Task difficulty was graded and improved by requiring speed or accuracy or by providing task that require more skilled usw
of involved hands.
Step9: Conventional physiotherapy treatment based on activities of daily living (ADL) includes weight shifting exercises, passive, active assistive and active range of motion exercises.
Step10: At end of each day, parents should be taught to engage the child in home practice of bimanual activities for 1 hour.

Activities improving the fine motor function include:
Dough activities – Roll large ball between 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).
Cube activities — Transferring cube from non-affected to affected hand and towering cubes. Started with 3 cubes till 6 cubes (first tower with the uninvolved limb and then with the involved one).

a) Bottle and marble activities — Put marbles into bottle. First the affected hand stabilized the bottle and the child performed the task with the unaffected hand.
e) Stacking rings — child held the rings with large one and stack with the non-affected hand and put rings on with the affected hand.

STATISTICAL ANALYSIS

Statistical analysis was performed using MS excel and graph pad. The demographic data like standard deviation and main percentage were calculated and presented.
BETWEEN THE GROUPS: Independent t-test was performed which assess the statistical difference in mean values between the groups.
WITH IN THE GROUPS: Paired t-test was performed which assess the statistical difference with in the groups.
To observe the impact of treatment before and after in the groups, the analysis was carried out using statistical tests, for the outcome measures PDWS scale and MAS scale are used.
The statistical significance was set at p <0.0001.

Table-I: pre and post values of Peabody developmental motor scale on hand arm bimanual therapy technique.

<table>
<tr><th>PDMS</th><th>MEAN</th><th>STANDARD DEVIATION</th><th>P-VALUE</th><th>T-VALUE</th></tr>
<tr><td>PRE-TEST</td><td>14.70</td><td>3.335</td><td rowspan="2">< 0.0001</td><td rowspan="2">2.685</td></tr>
<tr><td>POST-TEST</td><td>18.70</td><td>3.335</td></tr>
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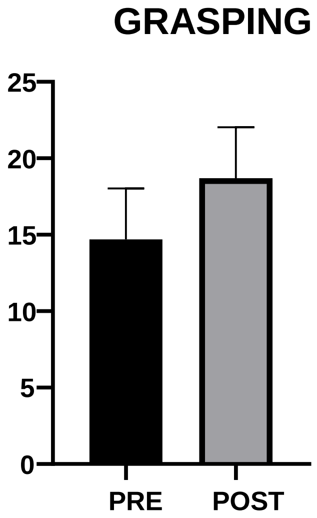
Graph-I: mean scores of pre and post values of grasping with Peabody developmental motor scale.
GRASPING



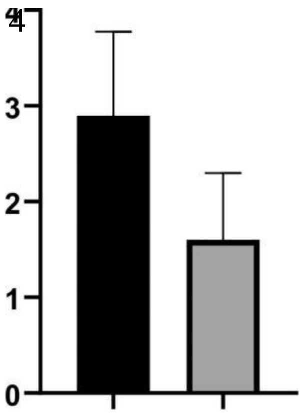
RESULT: The above table and graph show mean values changes within the PDMS from pretest and post-test were found to be statistically significant. (p <0.0001).

Table-2 pre and post values of modified Ashworth scale on hand arm bimanual therapy technique.

PDMS	MEAN	STANDARD DEVIATION	P-VALUE	T-VALUE
PRE-TEST	2.900	0.8756	< 0.0001	3.669
POST-TEST	1.600	0.6992		

Graph-2: mean scores of pre and post values of spasticity with modified Ashworth scale.

SPASTICITY



PRE POST

RESULT: The above table and graph show mean values changes within the MAS from pretest and post-test were found to be statistically significant. (p<0.0001).

RESULTS

The results in the study revealed that hand arm bimanual intensive therapy (HAIBT) shows significant reduction of spasticity in cerebral palsy children. Whereas that proves p values is <0.0001 by using PDMS modified Ashworth scale.

DISCUSSION

Cerebral palsy results in the limitation of activity, accompanied by impairment of sensory function, cognition, communication and perception. However, early treatment helps in reconstructing the damaged brain and is likely to improve the activities. It is proven that rapid growth and development of brain occurs during pregnancy.

This study has used task-oriented activities which consists of grasping, holding, removing pegs with bimanual use of hand arm in spastic cerebral palsy children. Pretask practice involve targeting movement exclusively of other movements. For example, making different shapes with clay targeting precision grasp.

Manipulative gross motor activities like throwing and catching a ball were also included in HABIT. Whole task practice involved targeted movements spatial and temporal coordination within the context of completing task. For example, during drawing the objective was to complete the picture using a Colored sketch.

Task difficulty was graded as the child's performance improved by increasing the speed.

For example, making different shapes using clay as fast as possible.

In this study we followed PDMS (FINE MOTOR) score after intensive treatment and found that the improvement of fine motor function was maintained during 6weeks. PDMS scores significantly improved fine motor activities like grasping, drawing, throwing a ball in CP children with age group of 1-5 years.

There are other studies where only fine motor functions were improved with less duration. In the present study, improvement is seen in fine motor function and reduced spasticity with short time.

In this study, consequently will interfere with the hand function performance, so the current study was conducted to detect the effect of handarm bimanual intensive therapy on changing the affected upper extremity motor performance in those children.

The results of the current study showed decreased hand grip strength which may be explained by the effect of spasticity that leads to change in the muscle length. This can be supported by Salter and Cheshire [18] who reported that, 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.

Improvement in the study group Peabody scores of the grasping section and age equivalent of motor performance in the current study may be attributed to the effect of hand- arm bimanual intensive therapy as this type of therapy differs from conventional physical and occupational therapy in at least two ways: (l) the intensity of training is far greater, providing sufficient opportunity for practice using principles of motor learning; (2) encouraging the use of the involved hand in any manner as the child was asked to use it as a typically developing child uses their non dominant hand, and in particular to focus on how the hand and arm are performing at the end-point of the movement [19]

The significant difference in Peabody developmental scores between the study and control groups may be attributed to the effect of hand-arm bimanual intensive therapy which allowed patients of the study group to simultaneously receive proprioceptive and visual feedback from the unaffected limb (as in rolling dough against the table) that they do not receive during unilateral practice in which only the affected limb is used in the control group. This explanation is supported by Stephen et al. [20] who reported that when practicing bilaterally, a patient can use the unaffected extremities that have neurologically intact afferent and efferent signals as when looking and feeling movement within the unaffected limb, this will enable him to promote similar movement by the affected limb.

The current study depends on using both upper extremities simultaneously to facilitate the use of the affected upper extremity which is supported by the study of Hussien et al. [21] who recorded improvement in shoulder and elbow joint angular displacement after using arm cycling due to improved coordinated movements between the two sides, as arm cycle provided improvement in bimanual motor performance.

Post-treatment difference between both groups may also be explained as hand-arm bimanual intensive therapy which simultaneously activates the same neural networks in either hemisphere which decreases the interhemispheric 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 interhemispheric communication and ipsilateral motor cortex activation of the affected hemisphere [22,23].

Also, Mudie and Matyas [24] reported that, bilateral simultaneous movement promotes interhemispheric 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.

CONCLUSION

In this study patients with spastic cerebral palsy showed improvement in fine motor function after using the hand arm bimanual intensive therapy (HABIT) intervention. As patients are advised to perform task-oriented activities like grasping, holding, removing pegs, fine motor skills were improved.

The study was for 6weeks spasticity showed to be reduced with improved grip. Using Modified Ashworth scale spasticity was checked and PDMS is used to check fine motor function.

LIMITATIONS AND RECOMMENDATIONS :

The current study was limited with small sample size.

No control group.

Children between 0-lyears and >5 years of age were not included as it is beyond PDMS Scale.

Maximum children were in the age group of 1-3 years. Hence, effects of HABIT during >4 years were not evaluated.

The study focused only on fine motor function and reducing disabilities and no associated problems related with cerebral palsy.

RECOMMENDATIONS

l) A large sample size can be selected.

Study duration should be more with more sessions.

Long term outcome should be known by further studies.

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