FLEX CEUs

Cerebral Palsy Motor Control Advancements

A Study to Analyze the Effectiveness of Functional Strength Training in Improving Gross Motor Function among the Children with Spastic Diplegic Cerebral Palsy

Abstract

Objective: To compare the efficacy of functional strength training in improving gross motor function among the children with spastic diplegic cerebral palsy.

Design: Experimental study design with pre-test and post-test.

Background: The primary goal of rehabilitation for spastic dipelgic cerebral palsy is functional enhancement by maximizing the independence, life style, and dignity of the patient. A new development for treatment in specialized and well organized manner generated by different neurological treatment approach includes functional strength training. There has been less research explaining about the importance of functional strength training for improvement in functional activities.

Method: Fifteen subjects spastic diplegic cerebral palsy were selected under purposive sampling technique and received functional strength training for a period of 10 weeks.

Outcome measure: Gross motor function measure-the gross motor function measure is a standardized observational instrument designed to measure changes in gross motor function over time in children with CP.

Results: Statistical analysis done by using student's t-test and showed that there was significant improvement in subjects who received functional strength training.

Conclusion: The statistical results show that there is an improvement in gross motor function after 10 weeks of functional strength training program

Keywords: Cerebral palsy; Functional strength training; Gross motor function

Introduction

Cerebral palsy (CP) is a common developmental disability that affects thousands of babies and children each year. In India, the prevalence of Cerebral palsy is high. Cerebral palsy is characterized by motor dysfunction due brain damage in children usually associated with disabilities ranging from total dependency and immobility to abilities of talking, independent self-care and gross motor functions including standing walking, running and jumping. This condition poses considerable diagnostic challenges with degree of involvement ranging from minimal disability to severe and associated with severe co morbid conditions. Cerebral palsy is primarily a disorder of movement and posture. The children who have taken proper and regular therapy with earlier intervention they will be promoted as near normal children. The least expected by a parent in these children is to be independent on the gross motor function particularly the functions of standing, walking, running and jumping in the age group of 4-6 years. 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]. It is a common problem the worldwide incidence is being 2 to 2.5 per 1000 live births. The majority of people with CP have the spastic syndrome of which diplegia is the commonest. Low birth weight infants are at greater risk of developing CP than larger birth weight babies. The most important risk factor seems to be prematurity and low birth weight with the risk of CP decreasing gestation age and birth weight [1].

Despite being complex and heterogeneous condition, all cases of CP are ultimately caused by a neurological problem namely a lesion in the brain. The lesion is acquired at some point early in development, either during gestation while the fetus is in the mother's womb, during or soon after delivery or at any time up to two years. Prenatal causes are uterine infections, Thyroid abnormalities, Methyl mercury expose during pregnancy, Seizure disorder in the mother and multiple gestations. Perinatal causes are Forceps delivery, Breech presentation, perinatal asphyxia and intrauterine growth retardation. Postnatal causes are Bacterial meningitis, viral encephalitis, Hyperbilirubinemia and Problem with lungs and heart [2]. Cerebral Palsy is classified based on the type of neuromuscular deficit into 3 types as 1. Spastic 2. Ataxic 3. Athetoid. Spastic type is the most common and accounts for 70 to 80% of all the cases in which some of the muscles in the body are tight and weak, drawing of the limbs in and making control of movement is difficult. The spastic CP contains variations includes monoplegic, diplegic, quadriplegic and hemiplegic [3].

Spastic Diplegic CP is the commonest and it occurs due to the particular type of brain damage inhibits the proper development of UMN function impacting the motor cortex, the basal ganglia and the corticospinal tract. No type of CP is officially a progressive condition and indeed spastic diplegia does not clinically get worse given the nerves damaged permanently at birth neither recover nor degrade. Spastic diplegic CP is entirely congenital in origin that is almost always acquired shortly before or during a baby's birth process. The most common cause of spastic diplegia is periventricular leucomalecia more commonly known as neonatal asphyxia. Above the hips, persons with spastic diplegia typically retain normal or near normal muscle tone and ROM, though some lesser spasticity may also affect the trunk and arms depending on the severity of the condition in the individual. In addition, because leg tightness often leads to instability in ambulation, extra muscle tension usually develops in the shoulders, chest, and arms due to compensatory stabilization movements. Regardless of the fact that the upper body itself is not directly affected by the condition [3].

Toe walking with flexed knees are common attributes in crouched gait, whereas the scissoring gait is mainly present with adducted and internally rotated hips with inverted foots. The degree of spasticity in spastic diplegia varies widely from person to person. No two people with spastic diplegia are exactly alike. Balance problems and/or stiffness in gait can range from barely noticeable all the way to misalignments so pronounced that the person needs crutches or a cane to assist in ambulation. Less often, spasticity is severe enough to compel the person to use a wheel chair. In many cases, the IQ of a person with spastic diplegic CP may be normal however other side effects like strabismus are common. The impairments of spastic diplegic children are spasticity in lower limbs, ROM deficits and selective motor control problems. These impairments may limit the performance of gross motor, fine motor with limitations of participation in daily life [1].

The management of patients with CP must be individualized based on the child, clinical presentation and requires a multidisciplinary approach. The common treatment given to the cerebral palsy children are 1. Medications, 2. Surgery, 3. Physiotherapy, 4. Occupational therapy, 5. Speech therapy. Traditional physiotherapy used in children with CP has been shown to improve muscle strength, local muscular endurance and overall joint ROM. Routinely used as a part of interdisciplinary treatment approach for school aged children because it fulfills the need for certain degrees of cooperation and active participation on the part of the child.

Functional Strength Training

The strength training is given based on the functional activities mainly to focus on the functional limitations and to improve the quality of life. The functional strength training is designed to incorporate task and context specific practice in areas meaningful to each patient with an overall goal of functional independence. In the case of CP the exercises included in the functional strength training are more focused about the children independency in the school.

The functional strength training has been shown that task specific training yields long lasting cortical re organization which is specific to the areas of brain being used with a task. Studies have also shown that patients making larger gains in functional tasks used in habilitation and since they are more likely to continue practicing these tasks in everyday activities. Better results during follow up are obtained. The functional strength training is mainly dealt with anti-gravity muscles and aiming at maximal carry over in day to day activities. The functional strength training can be given by the use of resistance and it may be gravity, body weight, resistance bands and free weights. The exercises are specific to the muscle or muscle groups recruited during the functional activities [4]. This study was aimed to give awareness among the practicing physiotherapists regarding the misconception about the strength training in cerebral palsy. This study was done to find out the effectiveness of functional strength training in improving gross motor function among the spastic diplegic children [5-10]. A single group study to evaluate the effectiveness of functional strength training in improving gross motor function among the children with spastic diplegic CP [11-17]. The study will assess the improvements in the gross motor function after functional strength training program in spastic diplegic children and measure improvement the child functional independency in school environment.

Functional strength training

It is the practice of motion against resistance to build strength, balance and coordination and to improve the ability to perform day to day activities [18-21].

Gross motor function measure

The gross motor function measure is a standardized observational instrument designed to measure changes in gross motor function over time in children with CP [2].

Spastic diplegia

Historically known as Little's Disease, is chronic neuromuscular condition of hypertonia and spasticity manifested as an especially high and constant "tightness" or "stiffness" in the muscles of the lower extremities of the human body, usually those of the legs, hips and pelvis [2].

Materials and Methodology

A Study design adopted was a Single group pre-posttest, randomized control study. This study was conducted at, Outpatient department, RVS Hospital, Sulur and Amrit centre for special needs, Mettupalayam road, Coimbatore. The study was conducted for a period of 1 year and In the 1 year study duration intervention was given for the period of 10 weeks. Fifteen subjects who fulfilled inclusion, Age group 4 to 6 years, Sex Both boys and girls, Children under Gross motor function classification system level of I- III, Children with Spastic diplegic CP and able to understand the commands were selected and underwent functional strength training program. Children with Instable seizures, Mental retardation, Children underwent surgery, Children under Botox injection, other type of CP, GMFCS level IV- V were excluded. 15 subjects were selected based on the selection criteria and their gross motor function was measured by GMFM before the intervention. The parents were informed about the assessment, intervention and risk of participation of the study. After 10 weeks of functional strength training program posttest assessment was done.

Functional strength training

After finishing the pretest assessment the exercises were selected for each child based upon gross motor limitations observed by the therapist. The functional strength training exercises were given to strengthen lower limb muscles, improve segmental control of lower limbs and improve balance. The intervention was given 4 times per week. Each session lasts for 60-90 mins. Each session started with a warming up and cooling down period of 10 mins. During the warm up period muscle stretching, gentle massages for major muscles and aerobics given. The training session was carried out with a practice of loaded sit to stand, forward step ups, lateral step ups, leg press and half knee exercises. Sit to stand exercise was performed in the following manner. The child move the trunk by flexion of the hips until the shoulders are above the knee joints and then the child should stand up. The child should stay in that position for 5 sec. Standing with as much symmetrical hip strategy as possible to defined position. This is achieved by simple overhead activities.

The main strategy followed for the step up was, the child should place the right foot on the step next to the left foot and extend the knees as much as possible. Keep standing with both legs for 1 sec. Then place the right foot down then left with 8 repetition of same exercise. Then the exercise was carried for the other side also. The same procedure was followed for lateral step up exercise. Rest period 2 min in between each exercises. The leg press exercise was carried out in the leg press machine. The repetition of leg press during the overall circuit training was less because it is not a functional one. The half knee exercise was carried out in the floor and the weight bearing mainly carried out in leading leg during the transmission. The therapist was standing in front of the child to provide support while coming up from the half kneeling posture. In each activity one stand up and one return was considered as 1 repetition. Orthosis were used in some children who were having tight tendo- achilles to maintain the heel contact.

The exercises were carried out in circuit manner. Exercises were performed intensively with 8 repetitions in order to promote motor learning and improve muscle strength and endurance. The training was completely individualized and exercises were given with attention to each child to get correct performances of the exercises. The exercises were given through goal directed game like activities with little fun to get maximum active participation from the child and to make the child enjoy the session. The resistance was given by the means of weight cuffs and weight vest. The parents kept a diary to record all the exercises performed during the session. Remaining 2 days of the week parents are instructed to make the child to do those exercises without resistance excluding on Sunday. The exercises were progressed by increasing the number of repetitions and exercise difficulty. After 10 week functional strength training program posttest assessment was done (Table 1).

Measurement Procedure

It is a standardized observational instrument tests activities in 5 dimensions lying and rolling, sitting, crawling and kneeling, standing and walking, running, jumping. In this study dimension D, (i.e.) standing, dimension E (i.e.) walking, running, and jumping were selected as goal areas. According to the scoring sheet activities were scored as 0, 1, 2, 3, NT by observing the child's performance with higher rating represents the better performance. During each activity the level of support, balance reactions, weight transmission and the type of assistances all were noted.

S.NO	INTERVENTION	REPETITION	DURATION
I	**WARM UP:** Streching Hamstrings Quadriceps Tendoachilles Adductors of Hip	 Hold 10 Sec × 5 rep Hold 10 Sec × 5 rep Hold 10 Sec × 5 rep Hold 10 Sec × 5 rep	5-7 Min
II	**EXERCISE:** Leg Press Loaded sit to stand Forward step up Right Left Lateral step up Right Left Half knee Rise Right Left	 8 reps 8 reps 8 reps 8 reps 8 reps 8 reps 8 reps 8 reps	 8-10 min 8-10 min 8-10 min 8-10 min 8-10 min 8-10 min 8-10 min 8-10 min
III	**COOL DOWN:** Stretching (or) Walking	-	5-7 min

Table 1: Functional strength training drills.

Results

A number of subjects for the study was 15 (n=15). The subjects were involved for the pretest assessment by GMFM. Treatment was given for period of 10 weeks 4 sessions per week. Regarding the dependent variable dimension D (i.e.) standing, dimension the calculated't' value is 4.818 which is higher than the table value is 2.977.at 0.005 level. Hence the calculated't' value is more than table value, the above value shows that there is significant difference in standing after functional strength training. In dimension 'E' (i.e.) walking, running, and jumping of GMFM, the calculated 't' value is 18.14 which is greater than the table value 2.977 at 0.005 level. Hence the calculated't' value is more than table value, the above value shows that there is significant difference in walking, running and jumping following functional strength training.

When analyzing both dimensions there is significant improvements in both dimension D&E of GMFM. Therefore the results show that the functional strength training having significant effects in gross motor function among preschool age spastic diplegic children. Hence we accept alternate hypothesis and reject null hypothesis (Tables 2-4).

Discussion

Spastic children having particular type of brain damage that inhibits the proper development of UMN function impacting the motor cortex, cortico spinal tract and basal ganglia. Due to these areas involvement mainly the spastic diplegic children often more impairments in the movement than the sensory areas. In this study 15 children were selected based on the criteria and pretest was done at 0 week. The

s.no	characteristics	n
1	Walks without restrictions	**15**
2	Walks with assistive device	**5**
3	Children under Gross motor function classification system level of I- III	**I-7** **II-4** **III-4**
4	Male	**10**
5	Female	**5**
6	Age 4	**4**
7	Age 5	**7**
8	Age 6	**4**
9	Regular to school	**10**
10	Irregular to school	**5**

Table 2: Data analysis of dimension d of GMFM': Socio demopgraphics of 15 children with cerebral palsy and their families.

Intervention	Mean	Mean Difference	SD	Paired 't' Value
Pre Test Post Test	63.51% 84.95%	17.43	28.86	4.818

Table 3: Dimension D-Standing: shows mean value, mean difference, standard deviation and paired 't' value between pretest and post test scores of dimension D in functional strength training.

Intervention	Mean	Mean Difference	SD	Paired 't' Value
Pre Test Post Test	30.73% 44.68%	13.93%	2.971	18.14

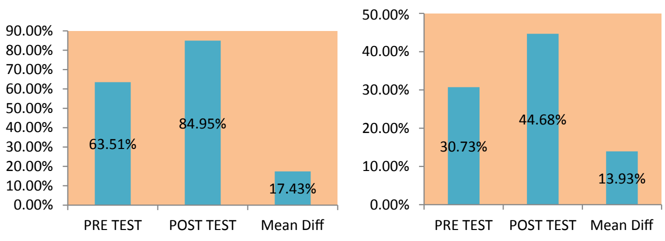
Table 4: Dimension E-walking, running and jumping: shows mean value, mean difference, standard deviation and paired 't' value between pretest and posttest score of dimension E of GMFM in functional strength training.

functional strength training was given for the period of 10 weeks based on the prescribed protocol. The findings in our study show that a 10-week functional strength training programme which is focused on the lower extremities improves walking ability. However l5 participants in this study could walk with or without walking aids and they all walked in a very typical way, with flexion, internal rotation and adduction in their hips and flexion in their knees. The antagonist muscles, hip abductors, and hip extensors are thus not normally activated and it could be assumed that they are weaker than in individuals with a normal walking pattern [22-25]. In many respects, functional strength training should be thought of in terms of a movement continuum. As humans, we perform a wide range of movement activities, such as walking, jogging, running, jumping, lifting, pushing, pulling, bending, twisting, turning, standing, starting, stopping, climbing and lunging. All of these activities involve smooth, rhythmic motions in the three cardinal planes of movement-sagittal, frontal and transverse. The functional strength training enhances the coordinated working relationship between the nervous and muscular systems. The task specific functional strength training yields long lasting cortical reorganization which is specific to the area of brain being used with a task. Training to improve functional strength involves more than simply increasing the force-producing capability of a muscle or group of muscles [26].

After finishing the pretest assessment, the calculated mean pretest score of dimension 'D' was 55.89 %. After the 10 week intervention programme the post test scores were measured and the mean value of the post test score was 66.49%. The mean difference of dimension D (standing) of GMFM is 10.59. So there was 10.59% increase in the dimension D (standing) of gross motor function measure due to the 10 week functional strength training. In dimension E (walking, running, jumping) the assessed mean pretest score was 29.43 and the posttest mean score was 38.79 [27-28]. By these we found that there was significant improvement in walking, running and jumping up to 9.35%. Therefore from the above analysis we could found the significant changes in overall gross motor function after 10 weeks functional strength training in the children with spastic diplegic cerebral palsy (Figure 1).

Conclusion

An experimental study was conducted to investigate the effectiveness of functional strength training in improving gross motor function among preschool age children with spastic diplegic CP. 15 children with age limit of 4-6 years were selected based on the selection criteria and they were treated with functional strength training exercises and gross motor function was measured by GMFM before and after the intervention. The statistical results show that there is an improvement in gross motor function in particular standing, walking, running and jumping after 10 weeks of functional strength training program.



Mean difference in dimension 'D' is 17.43 mean difference of in dimension 'E' is 13.93%.

Figure 1: Graphical representation of pretest mean and post-test mean scores of dimension D (standing) and E (walking, running, and jumping) of GMFM.

Limitations

1. Short duration study.
2. Sample size was small, which might have affected the generalization of the study
3. Age group between 4 to 6 was only selected for the study.
4. Spastic diplegic type of cerebral palsy was only considered.
5. The study only assessed short term progress of the patient. Long term follow-up is needed to evaluate the difference in the condition of the patient from current status.

Suggestions

1. Further study can be conducted with more sample size.
2. Further study can be done in other types of cerebral palsy including hemiplegic, athetoid and ataxic cerebral palsy.
3. Long term follow-up is needed to evaluate the difference in the condition of the Patient from current status.
4. Further study is suggested with Strength training can be given in progressive method.
5. Further study is needed to systematically determine the most efficacious protocol for each patient

Effect of Cage Therapy using Advanced Spider Suit Compared to Traditional Physical Therapy on Gross Motor Function in Children with Cerebral Palsy – An Indian Experience

Abstract

Objectives: Cerebral Palsy (CP) is a condition where non progressive disorders of posture caused by abnormal development of, or damage to, motor control centers of brain resulting in abnormal movements. Improving gross motor function in children with cerebral palsy has been a major aim of physical therapist. The purpose of this study is to find out the Effect of Cage Therapy using Advanced Spider Suit Compared to Traditional Physical Therapy on Gross Motor Function in Children with Cerebral Palsy.

Materials and Methods: A comparative study was conducted to find out the effect of Cage Therapy using Advanced Spider Suit Compared to Traditional Physical Therapy on Gross Motor Function in Children with Cerebral Palsy.

10 children with cerebral palsy were selected for this intervention. Age group between 4-8 years With GMFCS level III-IV were selected for this study.

In 10 children we have 2 Hypotonic, 2 hemiplegic and 6 Spastic diplegic kids. These subjects were equally distributed in each group.

Intervention: Therapy lasted for 8 weeks (5 days a week and 2hrs/day).

Group A - 5 subjects were subjected to Cage therapy using advanced spider suit.

Group B – 5 subjects were subjected to traditional physical therapy.

Gross Motor Function Measure was used to assess gross motor abilities of the subjects before and after intervention.

Results: The result showed significant improvement with Cage therapy using advanced spider suit therapy than traditional physical therapy on Gross Motor Function Measure.

Conclusions: The Cage Therapy using Advanced Spider Suit is more effective and beneficial therapy than Traditional Physical Therapy in improving Gross Motor Function in Children with Cerebral Palsy.

Keywords Cage Therapy; Spider Suit; Cerebral Palsy; GMFM

Introduction

Cerebral palsy is a condition where non progressive disorders of posture caused by abnormal development of, or damage to, motor control centers of brain resulting in abnormal movements - attributed to non-progressive disturbances that occur in the developing brain. The motor disorders of cerebral palsy are often accompanied by disturbances of sensation, cognition, communication, perception and behavior and by seizure disorder [1]. Around 8000-10000 babies and infants are diagnosed annually with cerebral palsy. Cerebral palsy is the second most common neurological impairment in childhood. The incidence of cerebral palsy is estimated to be around 2-2.5 per 1000 live births [2].

Over the past fifty years there is emphasis on prevention of CP, though research into affected children to promote gross motor development for children with Cerebral Palsy (CP) has focused on rehabilitation method, training method, or treatment method. However many of these studies have been inconclusive secondary to methodological bias or limitation such as small samples, inappropriate outcome measures, improper study design, or lack of standardization of experimental procedures [3].

Gross Motor Function is a major debilitating factor for the performance of activities of daily living in children with cerebral palsy. Recent evidence suggests that children with CP may improve gross motor function if provided opportunities to practice in right way.

One treatment approach that is becoming popular is Cage Therapy along with Advanced Spider Suit.

The Cage Therapy Unit is a unique and dynamic device consisting of a system of pulleys, straps, and splints utilized to perform a variety of exercise. This system improves strength, passive and active range of motion, and muscle flexibility. With the use of this system, the therapist can isolate any muscle group and target. In this situation the muscle tone (usually increased) does not influence the movements. This allows muscle groups to counteract the spastic muscles. The end effect is functional gains. The quality of gait, balance, and coordination of movements increases rapidly.

The key elements of Cage Therapy Unit are:

The "Monkey Cage" is a tri-dimensional rigid metal cage where metal pulleys are arranged to stretch and strengthen muscles groups.

The "Spider Cage", therapist uses leather belt in which bungee cords are connected. In this way, the patient is supported and can safely learn weight shift, jump, kneel, half-kneel and step up and over objects. The "spider cage" is an effective tool for implementing neuro-development treatment (NDT), one of the most wide-spread and clinically accepted methods for "re (programming)" the central nervous and neuromuscular systems and "teaching" the brain more adequate motor skills.

Advanced Spider Suit is a soft dynamic orthotic which consists of a cap, vest, shorts, knee pads and special adapted shoes that are interconnected with elastic bands. The basic concept of the Advanced Spider Suit is to create a supporting unit to align the body as close to normal as possible re-establishing correct postural alignment and weight bearing which is fundamental in normalizing muscle tone, sensory and vestibular function. The elastic bands are adjustable, which means that we can load the body axially within 15 to 40 kg.

The Advanced Spider Suit is the most modern type of suit available today.

Traditional Physical Therapy Program is designed of specific sets of exercises to work towards 3 important goals:

a) To maintain or improve muscle property

b) To avoid contractures and to improve the child's motor development

c) Activities and muscle re-education exercises to improve flexibility, strength, balance & co-ordination.

Strengthening muscles and improving function, contributes to gains in range of motion, both active and passive, and improved muscle flexibility and tone, promoting good benefits [7,8] as for the cerebral palsy population. According to Wu et al. [9], passive stretching combined with engaging in active movement training with CP children demonstrated improvements in joint biomechanical properties, motor control performance, and functional capability in balance and mobility. Children's physical development and movement is linked closely to other aspects of their daily learning. It is influenced by their growing confidence and enjoyment of physical play, by their increasing ability to control their own bodies through movement and by their physical well-being and strength [10].

Materials and Methods

Study design

A comparative study was conducted to find out the effect of Cage Therapy using Advanced Spider Suit Compared to Traditional Physical Therapy on Gross Motor Function in Children with Cerebral Palsy.

Sample

10 subjects were selected after giving due consideration to inclusion and exclusion criteria. In 10 children we have 2 Hypotonic, 2 hemiplegic and 6 Spastic diplegic kids.

Sampling method

Random sampling technique was used to select the samples.

Inclusion criteria

Diagnosis of Cerebral palsy

Both gender with children aged 4 to 8 years

Gross Motor Function Classification System level III-V.

Exclusion criteria

Subluxation or dislocation of hip exceeding 33%

Scoliosis exceeding 25 degrees

Osteoporosis

High blood Pressure

Complicated systemic disorders

Uncontrollable seizures

Usage of Botulinum toxin A injection within 3 months of prior study.

Outcome Measures

Gross motor function measure (GMFM)

The Gross Motor Function Measure (GMFM) is a clinical tool designed to evaluate change in gross motor function in children with cerebral palsy. There are two versions of the GMFM - the original 88-item measure (GMFM-88) and the more recent 66-item GMFM (GMFM-66). Items on the GMFM-88 span the spectrum from activities in lying and rolling up to walking, running and jumping skills. The GMFM-66 is comprised of a subset of the 88 items identified (through Rasch analysis) as contributing to the measure of gross motor function in children with cerebral palsy. The GMFM-66 provides detailed information on the level of difficulty of each item thereby providing much more information to assist with realistic goal setting.

This is a single test retest case report using the Gross Motor Function Measure-88 (GMFM-88). A baseline measurement was taken to provide a basis for comparison with the new intervention. The GMFM-88 baseline measurement was scored two times: once without AFO's and assistive devices and a second time with AFO's and assistive devices. The GMFM is a criterion-referenced measure based on the concepts of abilities and limitations in gross motor function and is analogous to the staging and grading systems.

Procedure

Ten subjects aged between 4-8 years with cerebral palsy were selected based on inclusion and exclusion criteria and divided into two groups namely Group A and Group B. All these subjects were assessed using a general assessment pro forma that recorded Gross Motor Function Measure.

Group A

The subject received two hours/ day for five days in a week for two months of Cage therapy with Advanced Spider suit which includes:

a) General warm up and mild stretches followed by Monkey Cage therapy – Basically to improve strength by isolating muscle group without compensating with other muscle group (weights and pulley system)

b) Spider Cage therapy to improve Co-ordination and Balancing and assisted movements like sit to stand, quadruped, squats, and jumping.

The therapist guides the child through exercises to strengthen muscles and allow the patient to experience movements.

Group B

The subject received Traditional Physical therapy for two hours/ day for five days in a week for two months which includes:

a) General body warm up exercises

b) Passive and active assisted range of motion exercises for all the joints.

c) Muscle Stretches and flexibility exercises

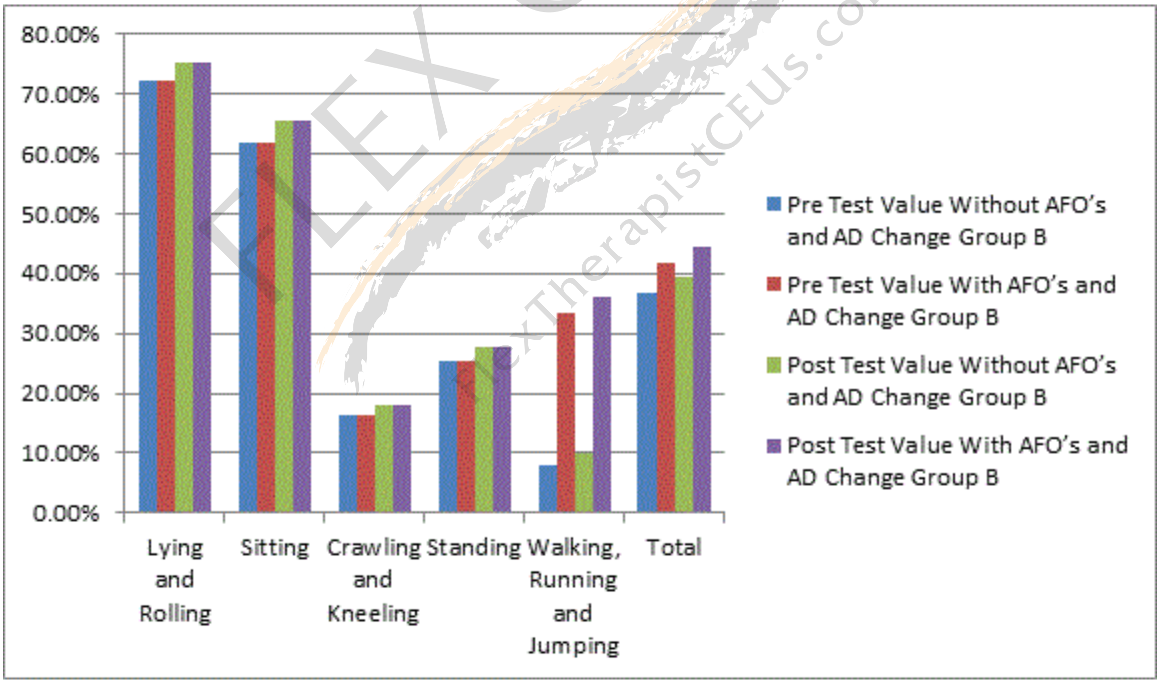
d) Strengthening exercises with weights and resistance band.

e) Balancing and co-ordination exercises

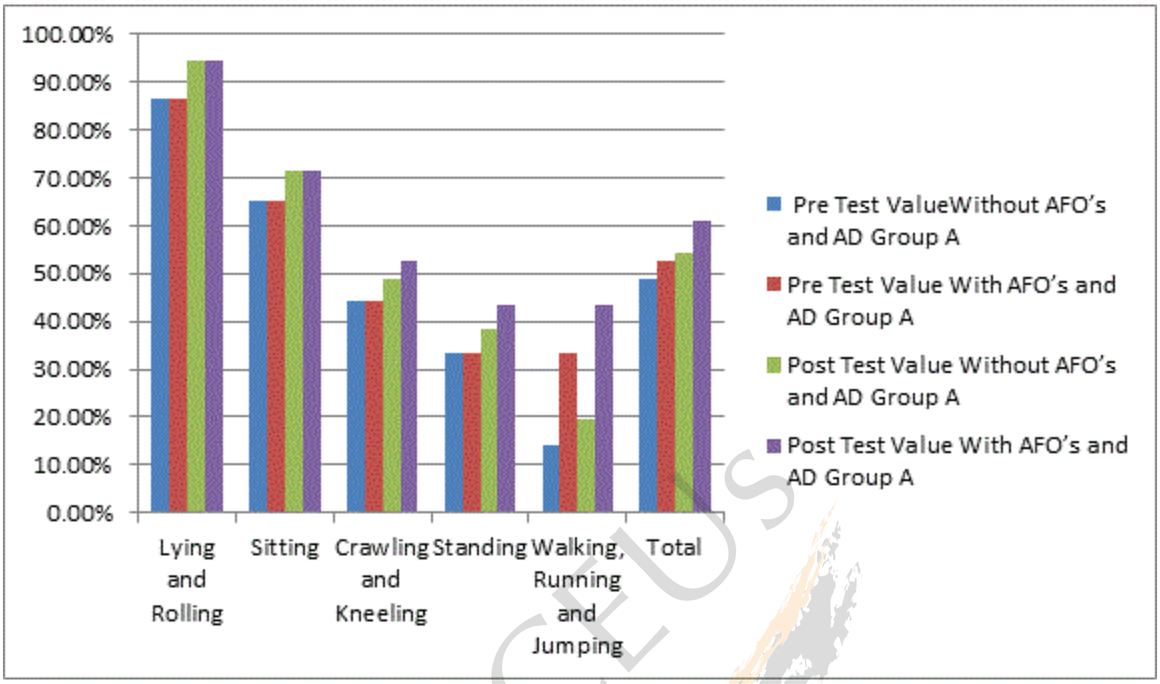
Results

The aim of the study was to find out the effectiveness of Cage Therapy using Advanced Spider Suit Compared to Traditional Physical Therapy on Gross Motor Function in Children with Cerebral Palsy.

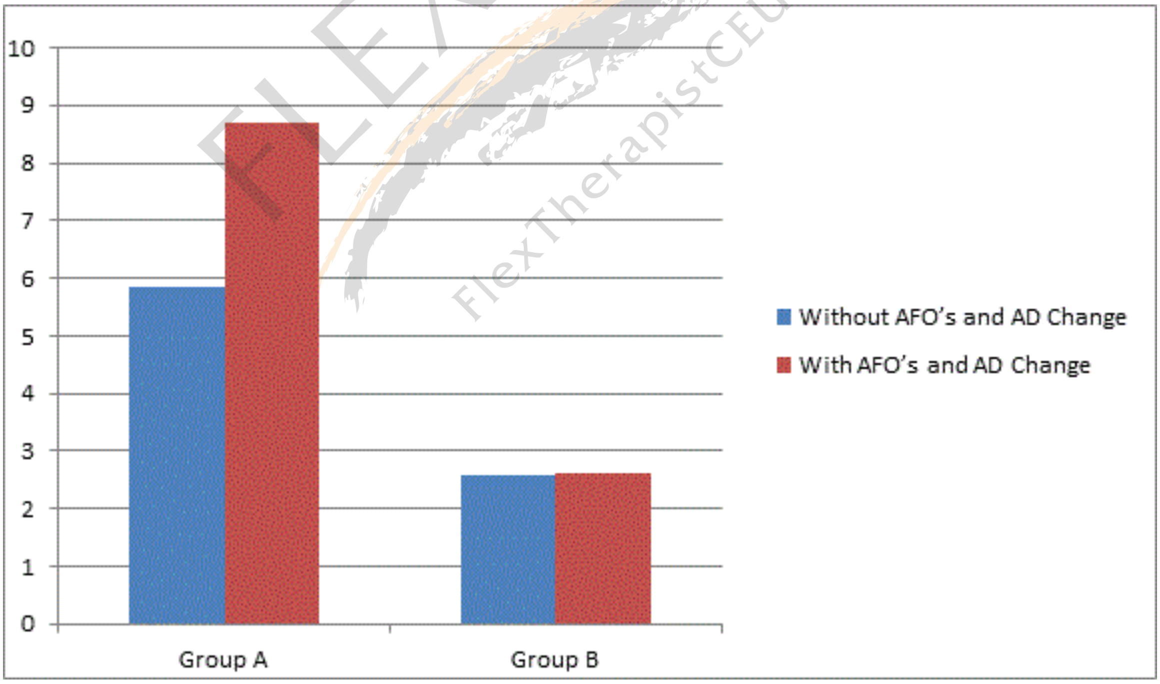
Histogram 1-3 shows Group A and B Motor Function Measure Pre and Post Test Result.



Histogram 1: Group A gross motor function measure pre and post test result.



Histogram 2: Group B gross motor function measure pre and post test result.



Histogram 3: Post-test comparison between Group A and B.

Table 1 displays the GMFM values of Post-test therapy program. The result showed significant difference in improvement of GMFM values in GROUP A (Without AFO's and AD Change = +5.84, With AFO's and AD Change = +8.71) which is greater than the Group B (Without AFO's and AD Change =+2.58, With AFO's and AD Change =+2.63).

Group A		Group B	
Without AFO's and AD Change	With AFO's and AD Change	Without AFO's and AD Change	With AFO's and AD Change
+5.84	+8.71	+2.58	+2.63

Table 1: Post-test comparison

Discussion

Present study was done to find out the effectiveness of Cage Therapy using Advanced Spider Suit Compared to Traditional Physical Therapy on Gross Motor Function in Children with Cerebral Palsy (Figure 1).

Figure 1: Subject with Spider suit performing exercises in Cage Therapy Unit.

This Advanced therapy had been proven to be effective in improving Gross Motor Function in children with cerebral palsy in this study with limited number of children. The reason behind this improvement can be the number of sessions of therapy (2hours/day and 5 days a week for 2 months), Benefit of Advanced Spider Suit which provides external stabilization to the trunk and therefore allows more fluent and coordinated movement for both upper and lower extremities with combination of Spider Cage Therapy and Monkey Cage Therapy. Large multi-centre randomized control trials are essential to confirm our findings. But this provides a promising future with better patient satisfaction for children with CP.

Conclusion

The Cage Therapy using Advanced Spider Suit is more effective and beneficial therapy than Traditional Physical Therapy in improving Gross Motor Function in Children with Cerebral Palsy.

The Cage Therapy using Advanced Spider Suit is customized to the needs of each cerebral palsy child, with specific functional goals and usually involves an intensive rehabilitation program. It combines the best elements of various techniques and methods. It is important to note that the use of the suit is only one component of an overall approach. Parental involvement is highly encouraged and parents are often part of the treatment program. It needs to be mentioned, however, that a true intensive therapy program is not merely doing the same exercise over and over again, but rather is a structured approach to physical activity with consideration to the person's individual cycles of progressive overload, fatigue and recovery.

Role of Spider Cage in Motor Control in Cerebral Palsy

Abstract

Cerebral palsy can be defined as disorder of movement and posture caused by lesion in immature brain. Brain lesion leads to abnormal sensory motor development along with visual, cognitive and hearing impairments. Motor control in normal individual is developed as body come under the influence of higher centers. Universal exercise unit, spider web, therasuit, functional training and repetitions of body transitions are used in these protocols. Therapy sessions are extended from three to four hours. It can be used with children and adults with different neurological conditions like stroke, cerebral palsy, spinal cord injury and spina bifida. Spider cage is made of metal with equal length, width and height, size of cage can be different depending upon type of population pediatric or adults. Cage consists of elastic cords and belts, which are used to support the patients in the cage. Different activities of functional training can be practice in this cage easily. Elastic resistance of cords can be used to strengthen the weak muscles. Initiation of a particular posture can be easily trained in this cage. Therapies and techniques are discovered over the time to treat patients with cerebral palsy. Although use of universal exercise unit in rehabilitation is not new, however in cerebral palsy it can be used with new concept. Scientific research literature is limited on its effectiveness.

Keywords: Cerebral palsy; Motor control; Universal exercise unit

Introduction

Cerebral palsy can be defined as disorder of movement and posture caused by lesion in immature brain [1]. Brain injury can occur in fetal life or during the first year of life by hypoxia, asphyxia, neonatal jaundice, traumatic brain infections and prematurity [2]. Brain lesion leads to abnormal sensory motor development along with visual, cognitive and hearing impairments [3]. Exact cause of cerebral palsy is still unknown; however brain damage can occur before birth, during the birth and after the birth. Pregnancy disorders are considered leading cause before birth [4]. Birth asphyxia, prematurity, neonatal infections and traumatic brain injury are some important causes in cerebral palsy [5]. Cerebral palsy has different types like spastic, athetoid, ataxic, hypotonic and some tome mixed type [6]. Cerebral palsy can be divided depending upon parts of body involve like monoplegia, diplegia, hemiplegia and quadriplegia, this is called topographical classification of cerebral palsy [7]. Gross motor functional classification categorized the children into level I (least disability) to level V (severe disability) depending upon the abilities and disabilities of child [8].

Universal Exercise Unit

Intensive protocols in pediatric physical therapy are getting popularity in cerebral palsy centers [9-15]. Universal exercise unit, spider web, therasuit, functional training and repetitions of body transitions are used in these protocols. Therapy sessions are extended from three to four hours. It can be used with children and adults with different neurological conditions like stroke, cerebral palsy, spinal cord injury and spina bifida. Spider cage is made of metal with equal length, width and height, size of cage can be different depending upon type of population pediatric or adults. Cage consists of elastic cords and belts, which are used to support the patients in the cage. Different activities of functional training can be practice in this cage easily. Elastic resistance of cords can be used to strengthen the weak muscles. Initiation of a particular posture can be easily trained in this cage.

Figure 1: One leg control.

Universal exercise unit can be used in different therapeutic posture (Figures 1-4). Continuous training of a specific posture in universal exercise unit enables the child to adopt that posture in participation.

Universal exercise unit can be used in adjunct to various different traditional physical therapy treatments like strength training, stretching, functional training and weight bearing on joints [16-18]. In intensive therapy session universal exercise unit is frequent part of treatment. Therapist has batter control of body and easy to induce the posture in this unit.

Figure 2: Half kneeling.

Figure 3: Quadruped training.

Figure 4: Standing with activity.

Conclusion

Therapies and techniques are discovered over the time to treat patients with cerebral palsy. Although use of universal exercise unit in rehabilitation is not new, however in cerebral palsy it can be used with new concept. Scientific reach literature is limited on its effectiveness.

Infra-low Frequency Transcranial Magnetic Stimulation Effectively Improves the Motor Function in Children with Spastic Cerebral Palsy

Abstract

Background: Cerebral palsy (CP) is one of the major diseases that lead to severe disability and seriously impacts the quality of life of children. Infra-low frequency transcranial magnetic stimulation (ILF-TMS) is a new technique of noninvasive brain stimulation that exactly regulates the power of specific neurotransmitters through a special magnetic field. Our study was in order to investigate the efficacy of ILF-TMS treatment in children with spastic cerebral palsy.

Methods: 113 spastic cerebral palsic children were randomly divided into two groups: conventional rehabilitation group and ILF-TMS treatment group, Healthy control group was established at the same time. In conventional rehabilitaion group, children were treated with conventional rehabilitation treatment; In ILF-TMS treatment group were treated with ILF-TMS in addition to conventional rehabilitation treatment. Neurotransmitter in the brain was recorded with encephalofluctuograph (EFG) before and after ILF-TMS treatment. Gross Motor Function Measure (GMFM), Fine Motor Function Measure (FMFM) and Gesell development scale (GDS) were used to comprehensively evaluate the motor function in children with spastic cerebral palsy.

Results: The results showed that the relative power of γ-aminobutyric acid (GABA) in spastic cerebral palsy was lower than that in healthy controls and was increased significantly after ILF-TMS treatment for 3 months. The relative power of glutamate (Glu) in spastic cerebral palsy was higher than that in healthy controls and was reduced significantly after ILF-TMS treatment for 3 months. After 3 months training period there was significant improvements on the GMFM (dimension B, dimension C and dimension D), FMFM (dimension A and dimension B) and GDS (gross motor DA and gross motor DQ) in the ILF-TMS treatment group when compared to conventional rehabilitation group.

Conclusions: These findings indicate that GMFM is a sensitive indicator to assess the treatment efficacy in children with spastic cerebral palsy and ILF-TMS treatment can improve the motor function through regulating neurotransmitters in brain.

Keywords: Spastic cerebral palsy; Infra-low frequency transcranial magnetic stimulation; γ-aminobutyric acid; Glutamate; Gross motor function measure; Fine motor function measure

Abbreviations

Ach: Acetylcholine; CP: Cerebral Palsy; DA: Dopamine; EFG: Encephalofluctuograph; FMFM: Fine Motor Function Measure; GMFM: Gross Motor Function Measure; GDS: Gesell Development Scale; Glu: Glutamate; 5-HT: 5-Hydroxytryptamine Amine; ILF-TMS: Infra-low Frequency Transcranial Magnetic Stimulation; NE: Norepinephrine; rTMS: Repetitive Transcranial Magnetic Stimulation; GABA: γ-Aminobutyric Acid

Introduction

Cerebral palsy (CP) is defined as a permanent disorder of the development of movement and posture, causing activity limitations that are attributed to non-progressive disturbances that occurred in the developing fetal or infant brain [1-3].

The motor disorders of cerebral palsy are often accompanied by disturbances of speech disorders, visual, sensation, perception, cognition, communication, and behaviour, by epilepsy and by muscle contraction and deformity of limbs [4-13]. With the development of the perinatology and the improved techniques of neonatal intensive unitthe neonatal mortality is reduced significantly, however, the incidence of CP has a tendency to increasement in recenty years [5,14,15]. CP can be classified as spastic, dyskinetic, ataxic, tonic and atonic types according to clinical characteristics c and spastic type accounts for 70% children with CP [16,17].

CP is one of the major diseases that lead to severe disability and seriously impacts the quality of life of children [7,11,12]. In addition to motor function, the level of intelligence structure is commonly an important factor to influence the quality of life in children with cerebral palsy [9,10,13]. The purpose of cerebral palsy management is not only to ameliorate the body morphology and motor function but also to improve the cognitive ability in patient with CP. Although it is timely and debilitated, conventional rehabilitation treatment remains the mainstay for CP therapy at present [18].

There is an imbalance of excitatory and inhibitory neurotransmitters in the brain of children with CP [19,20]. It has been known that repetitive transcranial magnetic stimulation (rTMS) can modulate cortical excitability by focally stimulating the cortical region and has therapeutic potential in children with dystonia [21–25]. Hummel et al found that an interhemispheric imbalance is evident in children with brain injury, and that rTMS treatment can restore this imbalance [26,27]. Several studies demonstrate that rTMS therapy cam improve the motor function [25-30] and working memroy in patients with stroke [31,32].

Infra-low frequency transcranial magnetic stimulation (ILF-TMS) is a new technique of noninvasive brain stimulation that exactly regulates the power of specific neurotransmitters through a special magnetic field (frequency less than 0.2 Hz, magnetic field intensity: less than 500GZ)[33]. The ILF-TMS maybe more safer than the rTMS due to its low magnetic field intensity [33]. Jianlan Xu et al. have reported that consecutive ILF-TMS treatment can recovery the power of the neurotransmitter in mouse [33]. We hypothesized that ILF-TMS can restore the imbalanced neurotransmitters in the brain and then improve the motor and cognitive ability of children with CP. In this study, spastic cerebral palsic children were randomly divided into two groups: conventional rehabilitation group and ILF-TMS treatment group. Assessmental parameters such as GMFM, FMFM, GDS and EFG have been used to comprehensively evaluate the efficacy of ILF-TMS on intelligence structure and motor function in children with spastic cerebral palsy.

Methods

Participants

A total of 113 spastic cerebral palsic children were recruited from Department of pediatric neurology and rehabilitation, First Hospital of Jilin University from May 2014 to September 2014. They were randomly divided into two groups: conventional rehabilitation group (n=53) and ILF-TMS treatment group (n=60). The healthy control group was established at the same time. Neurotransmitters in the brain were recorded by encephalofluctuograph (EFG) in both children with CP and healthy control before ILF-TMS intervention and then nurotransmitters in the brain were detected repeatedly at timepoints of 1 month and 3 months after ILF-TMS treatment, respectively.

Gross Motor Function measurement (GMFM), Fine Motor Function measurement (FMFM) and Gesell development scale (GDS) were used to comprehensively evaluate the intelligence domains and motor function in children between conventional rehabilitation group and ILF-TMS treatment group. Inclusion criteria for participation in the study included: (1) a diagnosis of spastic cerebral palsy; (2) age between 2 and 4 years; (3) ability to follow simple instructions. Exclusion criteria included: (1) debilitating illness before or during the study; (2) surgical procedure during, or up to one year prior to the study; (3) Botunum toxin injection Or baclofen intrathecal pump during or up to six months prior to the study; and (4) inability to follow commands. All the children and their parents or caregivers provided their written consent for their participation in this study, and this study was approved by the ethic committee of the first hospital of Jilin universtity. The trial registration number is ChiCTR-TRC-14004706.

Method

Children in the conventional rehabilitation group (n=53) were only Trained by conventional rehabilitation treatment (physical therapy, occupational therapy, speech therapy, chinese massage, hyperbaric oxygen and so on; once a day, 30 minutes every time for one item). Children in the ILF-TMS treatment group (n=60) were undergone with both conventional rehabilitation treatment and ILF-TMS treatment (once a day, 30 minutes every time, frequence: less than 0.2 Hz, magnetic field intensity: less than 500GZ). The main treatment parameters: γ-aminobutyric acid (GABA), Glutamate (Glu). Adjuvant treatment parameters: 5-hydroxytryptamine amine (5-HT), acetylcholine (ACh), norepinephrine (NE), and dopamine (DA). Neurotransmitters in the brain were recorded by EFG (Kangli-tech company limited, Shenzhen, China) at timepoints before and after ILF-TMS treatment for 1month and 3 months respectively. According to the result of EFG to set the parameters for treatment, using GMFM, FMFM and GDS to do comprehensive evaluation on the two groups before and after treatment for 1 month and 3 months. The GMFM, FMFM and GDS are reliable tools for assessing the motor function and intelligence structure of children with CP. GMFM is a referenced test developed and validated to examine gross motor function skills in children with cerebral palsy and measure changes as a result of intervention [34]. Evidence of the validity and reliability of the GMFM for use in children with cerebral palsy has been extensively established [35,36]. Fine motor function measurement is an important item that can reflect the level of development of fine motor function in cerebral palsic children. Wei Shi et al reported that the reliability, validity and responsiveness of the FMFM and the fine motor functioning of children with cerebral palsy could be effectively measured using the FMFM scale [37,38]. Gesell developmental scale is an instrument to evaluate the level of infant and toddler mental development though the developmental quotient (DQ) to reflect the mature of the neuromotor integrity and function and to reflect the potential of intellectual development.

Statistical Analysis

The data were expressed as median and range. The difference between groups was analyzed by the Friedman test using the SPSS16.0 software. A two-side P value of <0.05 was considered statistically significant.

Results

The demographic and clinical characteristics of the study participants

To detect the neurotransmitters between spastic cerebral palsyic children and healthy control, 113 spastic cerebral palsic children and 20 healthy controls were recruited in this study. There is a significant difference in gestational age and birth weight between the two groups, other difference about the demographic and clinical characteristics between the spastic cerebral palsic children and health control was not found (Table 1).To determine the effects of ILF-TMS treatment on the intelligence structure and motor function in children with spastic cerebral palsy, 113 spastic cerebral palsic children were randomly divided into two groups: conventional rehabilitation group(n=53) and ILF-TMS treatment group(n=60).There was no significant difference about the demographic and clinical characteristics between the two groups (Table 2).

Parameters	Spastic cerebral palsic children	Healthy control
Number of Participants	113	23
Age (months)	41.34 ± 5.27	39.28 ± 3.39
gestational age(months)	35 ± 1.21*	38 ± 1.25
Sex		
Male%	7869.03	1669.57
Female%	3530.97	730.43
Age of the mother at birthyears	27.45 ± 1.23	26.34 ± 3.24
Age of the father at birth years	28.53 ± 1.87	28.23 ± 2.87
Birth weight (kg)	2.7 ± 0.4*	3.3 ± 0.2

Table 1: The demographic of spastic cerebral palsic children and healthy control *P<0.05

Parameters	Conventional rehabilitation group	ILF-TMS Treatment group
Number of Participants	53	60
Age (months)	41.849.58	40.846.93
gestational age(months)	361.11	352.12
Sex		
Male%	3566.04	4371.67
Female%	1833.96	1728.33
Age of the mother at birthyears	27.543.24	27.365.25
Age of the father at birthyears	28.182.68	28.933.19
Birth weight (kg)	2.60.5	2.80.3
Delivery type%		
Natural childbirth	1528.3	1220
Cesarean section	3871.7	4880
History of birth asphyxia		
No%	3566.04	3863.33
Yes%	1833.96	2236.67
History of pathologic jaundice after birth		
No%	4381.13	5083.33
Yes%	1018.87	1016.67

Table 2: The demographic of conventional rehabilitation group and ILF-TMS treatment group

The relative power of neurotransmitters in spastic cerebral palsic children and healthy control

Neurotransmitters in the brain were recorded with EFG at time points before, 1 month and 3 months after treatment. The results showed that the relative power of GABA in spastic cerebral palsic children was lower than healthy controls and was increased significantly 3 months after ILF-TMS treatment when compared with pre-treatment (P<0.05, respectively, Figure 1A). The relative power of Glutamate in spastic cerebral palsic children was higher than healthy controls and was reduced significantly 1 month and 3 months after ILF-TMS treatment when compared with pre-treatment, respectively. (P<0.05, respectively, Figure 1B). While there was no significant difference was found about the relative power of 5-HT, Ach, NE and DA between spastic cerebral palsic children and healthy controls.

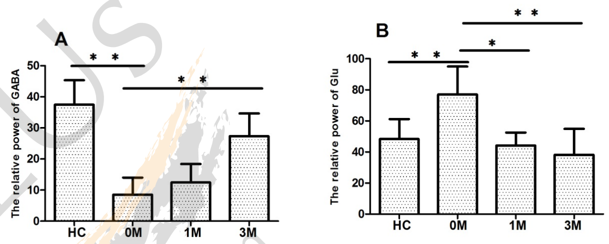


Figure 1: The relative power of GABA and Glu; (A) The changes of relative power of GABA in spastic cerebral palsy after ILF-TMS treatment for 3 months. (B) The changes of relative power of glutamate in spastic cerebral palsy after ILF-TMS treatment for 3 months (*P<0.05,**P<0.01).

The results of gross motor function were assessed by the GMFM

Gross motor function was assessed using the GMFM. No significant difference in the demographic data and pre-training baseline measures between two groups was found. We analyzed GMFM scores at each of the five dimensions for each child at timepoints as before, 1 month and 3 months after treatment, respectively.

The GMFM scores at each of the five dimensions (dimension A: Lying/rolling, dimension B: Sitting, dimension C: Crawling/kneeling, dimension D: Standing, dimension E: Walking/running/jumping) and total scores had an increasing tendency during the treatment in these two groups, however the improvement of gross mobility function in ILF-TMS treatment group was better than that in conventional rehabilitation group. The results indicated there was a significant difference in the scores in ILF-TMS treatment group compared to the conventional rehabilitation group for dimension B after treatment for1 month (P<0.05) (Figure 2A). Three months after training period significant improvement in ILF-TMS treatment group for dimension B (P<0.05), dimension C (P<0.05) and dimension D (P<0.05) of the GMFM was found compared to conventional rehabilitation group (Figure 2B and 2C).

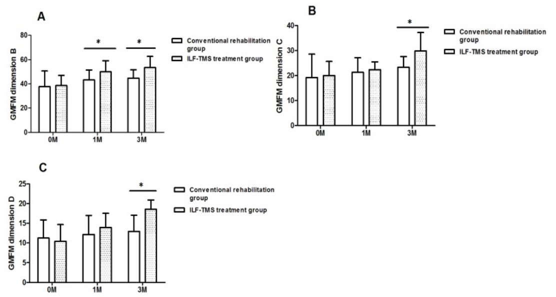


Figure 2: Results of Gross motor function assessed by GMFM in ILF-TMS group and conventional rehabilitation group (A) The changes of dimension B in GMFM in ILF-TMS group and conventional rehabilitation group (B) The changes of dimension C in GMFM in ILF-TMS group and conventional rehabilitation group (C) The changes of dimension D in GMFM in ILF-TMS group and conventional rehabilitation group (*P<0.05).

The results of fine motor function were assessed using the FMFM

Fine motor function was assessed using the FMFM. No significant difference in the demographic data or pre-training baseline measures between two groups was found. We analyzed FMFM scores at each of the five dimensions for each child before and after treatment.

The FMFM scores at each of the five dimensions (dimension A: visual tracking, performance, dimension E: Coordination ability between hands and eyes) and fine motor ability score had an increasing tendency during the treatment in these two groups. Furthermore, the improvement of fine mobility function in LIF-TMS treatment group was better than in conventional rehabilitation group. Moreover, no significant difference was found 1 month after treatment between the two groups. The results indicated that there was an significant differences in the scores in ILF-TMS treatment group when compared to the conventional rehabilitation group for dimension A and dimension B 3 months after treatment (P<0.05, respectively, Figure 3A and 3B).

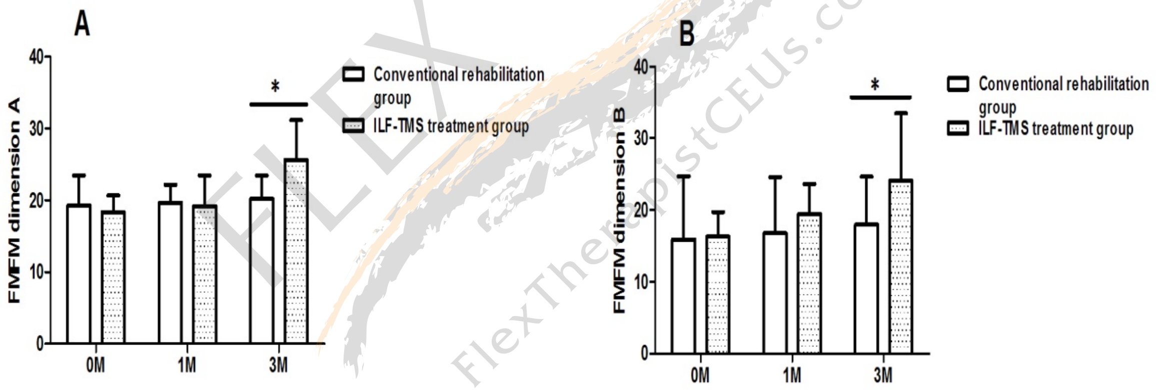


Figure 3: Results of Gross motor function assessed by FMFM in ILF-TMS group and conventional rehabilitation group (A) The changes of dimension A in GMFM in ILF-TMS group and conventional rehabilitation group (B) The changes of dimension B in GMFM in ILF-TMS group and conventional rehabilitation group (*P<0.05)

The results of Intelligence structure were assessed by the GMFM

Intelligence structure was assessed using the GDS. No significant difference in the demographic data or pre-training baseline measures between the two groups was found. We analyzed the GDS scores at each of the five domains for each child before and after treatment.

The GDS scores at each of the five domains (domain A: Gross motor DA/DQ, domain B: Fine motor DA/DQ, domain C: object adaptive ability DA/DQ, domain D: Speaking DA/DQ, domain E: personalsocial behavior DA/DQ) had an increasing trend after treatment in two groups. The results indicated that there was a significant differences in the scores in LIF-TMS treatment group compared to conventional rehabilitation group for gross motor DA and gross motor DQ 3 months after treatment (P<0.05, respectively, Figures 4A and 4B). However, no difference about domain B, domain C and domain D was found between two groups.

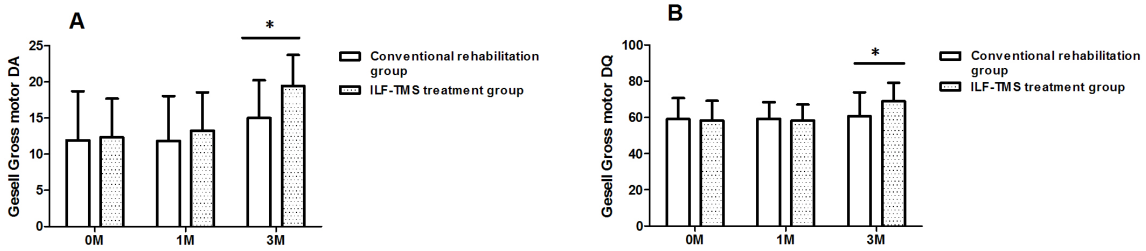


Figure 4: Results of intelligence structure assessed by GDS in ILF-TMS group and conventional rehabilitation group (A) The changes of gross motor DA in GDS in ILF-TMS group and conventional rehabilitation group (B) The changes of gross motor DQ in GDS in ILF-TMS group and conventional rehabilitation group (*P<0.05).

Discussion

The main findings in this study are: 1. the relative power of GABA in spastic cerebral palsy is lower than that in healthy controls and is increased significantly after ILF-TMS treatment for 3 months; the relative power of glutamate in spastic cerebral palsy is higher than that in healthy controls and is reduced significantly after ILF-TMS treatment for 3 months. 2. ILF-TMS treatment has improved the performance of CP children on GMFM and FMFM.

Preterm infants markedly increase the risk of CP. Studies examined risk factors in preterm infants [39-41]. Risk factors classically associated with CP in term infants such as preeclampsia, male gender, neonatal sepsis and Apgar scores were less important in preterm infants. Absence of antenatal steroids, growth restriction, and adverse events in the newborn period such as prolonged hypocarbia and postnatal steroids assume greater importance.

CP plays a serious burden to the individual family and society. Children and their families require significant additional support from medical, educational and social systems. The most important treatment at present for CP is timely, long-term, standardized rehabilitation training. Our research has shown that comprehensive rehabilitation can improve the development quotient and five domains including gross motorfine motoradaptationlanguage and individual-social domains. This demonstrates that conventional rehabilitation is still an important method for treatment of cerebral palsy [42].

GABA and glutamate are the two basic neurotransmitters in the brain in the mammalian central nervous system [43-46]. GABA is not only functionally but also metabolically linked with its excitatory counterpart glutamate,as glutamine is the precursor of both. GABA and glutamate, once released from neurons, are taken up into astrocytes, which convert glutamate into glutamine. Impairments of these glial-neuronal interactions result in nervous system diseases[47,48]. They were closely related with advanced functions such as memory, learning and cognition.

The results have shown that the relative power of GABA in brain in spastic cerebral palsy was lower than that in healthy controls and the relative power of Glutamate was higher than that of healthy controls. The changes of GABA and glutamate recorded with EFG in CP children are consistent with previous studies [49-53]. In this study, we use the conventional rehabilitation treatment combined with ILF-TMS treatment on spastic cerebral palsy. Neurotransmitter in the brain was recorded with EFG. We use the ILF-TMS treatment to improve the balance between GABA and Glu in the spastic cerebral palsic children. The relative power of GABA in spastic cerebral palsy was increased and Glu was reduced significantly after ILF-TMS treatment for 3 months. We think that ILF-TMS can regulate the function of neurotransmitter by a specific magnetic field generated in the brain. ILF-TMS has been reported in the central nervous system diseases widely [54,55].

Several reports have demonstrated that low frequency rTMS facilitates the recovery of motor function in children with a brain injury, suggesting that rTMS is a useful modality to improve the motor in disable patient due to cerebral impairment [56,57]. However, no paper about the effect of ILF-TMS treatment on the changes of motor function in spastic cerebral palsy has been reported. In this study, we use A battery of instruments such as of GMFM, FMFM and GDS to comprehensively evaluate the performance of CP children treated with ILF-TMS treatment. Analysis of the scores in the three tasks indicates that the children treated with ILF-TMS have performed better than those in the conventional rehabilitation group. To the best of our knowledge, this is the first report that ILF-TMS treatment can restore the balance of neurotransmitters such as GBAB and glutamate and improve the motor function and intelligence in children with CP. We deduce that ILF-TMS treatment maybe improve the intelligence structure and motor function in CP children through regulating neurotransmitters in brain.

There are some shortcomings of our present study such as small samples and short-term ILF-TMS intervention. A further larger sample and long-term study for ILF-TMS treatment for CP children is warranted. Above all, the present study has shown that ILF-TMS is effective in improve the motor function and maybe is a worthwhile choice in the treatment for CP children.

Transcranial Magnetic Stimulation Therapy in Spastic Cerebral Palsy Children Improves Motor Activity

Abstract

Transcranial magnetic stimulation (TMS) is a new interventional tool used in the study of neuronal activity and treatment of psychiatric disorders. Repetitive TMS (rTMS) is a non-invasive technique of stimulating the brain employing magnetic pulses. Recent research has demonstrated the efficacy of rTMS in facilitating motor functions. Using these evidences, we studied the effectiveness of rTMS in improving motor activity in spastic cerebral palsy (CP) children. CP is a neuro-developmental disorder of movement and posture that is caused by injury to the developing brain that restrict activities of daily living. In the quest to treat CP, several interventions are used among which physical therapy is the mainstay therapy. In this study, we selected 45 spastic CP children and divided them randomly into three groups-the reference group (RG) that was provided only physical therapy (PT) for 30 minutes daily for 20 days; the interventional group (IG) that was administered rTMS frequency of 5Hz (IG-A) and 10Hz (IG-B) for 15 minutes (1500 pulses) daily followed by PT as in RG. Gross motor function measure (GMFM) was used as assessment tool to evaluate the motor performance. Prior to start of therapy, pre-assessment of GMFM was performed on all participants and post assessment after completion of 20 sessions. The result was statistically significant in all three groups ($p<0.001$) and the mean change demonstrated 0.64%, 1.75% and 2.59% improvement in motor activity among participants in RG, IG-A and IG-B respectively. The study demonstrated positive effect of rTMS in improving motor activity when combined with PT.

Keywords: Cerebral palsy; Gross motor function measure; Physical therapy; Transcranial magnetic stimulation

Introduction

Transcranial magnetic stimulation (TMS) is a unique investigational tool used to study various neural processes and treat a variety of neurological illnesses due to its ability to directly modulate corticospinal and intracortical motor cortex [1]. Repetitive TMS (rTMS) is a non-invasive brain stimulation technique through which a focused magnetic field is delivered by a coil deep into the brain tissue. The repetitive pulses of the magnetic field stimulate neuronal activity in the target brain area by changing the pre-stimulus dynamics of neuronal firing in the stimulated region [2]. Recent studies have established that brain stimulation using rTMS can stimulate motor neurons that facilitate motor function in animals [3,4] and humans [5]. Kirton demonstrated the use of TMS on stroke and cerebral palsy (CP) patients that facilitated motor function after stimulating their motor cortex [6]. He further added that TMS can be employed in CP to study the activity and coordination of different parts of the brain by single or paired (repetitive) TMS pulses and to improve brain function [7].

CP belongs to a group of neurodevelopmental disorder(s) related to motor and posture impairment that develops in early childhood and persists throughout lifespan of an individual [8]. CP is caused by various etiological factors including prematurity, injury to developing brain, perinatal stroke, hypoxia, neonatal inflammation or infections; besides genetic variability [9]. Now-a-days, CP is regarded as a heterogeneous condition with multiple-causes, clinical types, neuropathology patterns, associated developmental pathologies (cognitive impairment, epilepsy, etc.) and rare genetic variations [10]. This heterogeneity gives rise to different forms of CP (spastic, ataxic, dyskinetic, athetoid), among which spastic CP is quite common and found in 70% to 80% of the cases. It is a neuromuscular impairment that limits the movement and posture of the body due to increase in the tonic stretch reflex or exaggerated tendon reflex in the muscles [11]. These patients are not able to perform activities of daily living (ADL) that involve movement and coordination of arm, leg and other body parts and thus fail to achieve developmental activities such as rolling, crawling, sitting, standing and walking. In order to improve the motor performance of spastic CP patients, various interventions [12] are combined with physical therapy such that motor function may be enhanced. Physical therapy (PT) teaches day-to-day movement skills such as sitting, walking, playing and dressing using cast's orthotics and provides muscle strengthening exercises [13]. In this study, we present our brief finding that demonstrates the effectiveness of rTMS when combined with PT in improving motor functions in spastic CP children in limited number of sessions.

Method

In this study, neuro-MS/D variant-2 therapeutic (Neurosoft, Russia) with angulated coil in the figure of eight (AFEC-02-100-C) and two channels of Neuro-EMG–MS digital system (for determining the motor threshold) were employed. The eight-shaped coil generates a magnetic field of up to 4 Tesla at the center of the coil that easily penetrates the cranium and enters the soft tissue of the brain. In this study, the coil was placed on the primary motor cortex which is known to be the motor pathway. This study was conducted after approval from the institutional ethics committee for human samples or participants (IECHSP), of the host institution and written consent from the parents or guardians of spastic CP children that met our inclusion criteria. Inclusion criteria followed were-willingness to participate; age group between 2 to 15 years; muscle tightness mild to moderate and cognitive deficiency nil to moderate, no metallic implants, no uncontrolled seizures or congenital diseases. Total forty-five children were selected from the out-patient department of UDAAN-for the different abled, Delhi, a non-profit organization that pioneered the rehabilitation of CP children using various interventions. The recruited children were randomly assigned into three groups in equal numbers– reference/ control group (RG), interventional group A (IG-A) and interventional group B (IG-B). RG consisted of 12 participants (mean age: 7.49 SD 4.95; male: 7, female: 5), IG-A consisted of 15 participants (mean age: 7.93 SD 4.86; male: 9, female: 6) and IG-B consisted of 14 participants (mean age: 8.06 SD 4.10; male: 10, female: 4). Three participants from RG and one from IG-B did not continue the study due to some unknown reasons; thus, their baseline data was not used for any statistical analysis.

The assessment of gross motor function of recruited children were performed using gross motor function measure (GMFM) which is an internationally approved scale used by trained physiotherapists to monitor motor development in spastic CP patients [14] and for assessing efficacy of any treatment [15]. GMFM is a performance based measure that reflects developmental milestones of a growing child (rolling, crawling, sitting, standing, walking/running) referred to as gross motor abilities of CP patients [16]. GMFM has total 88 assessment items which are grouped into five domains, namely A-lying and rolling (17 items), B-sitting (20 items), C-crawling and kneeling (14 items), D-standing (13 items), and E-walking, running and jumping (24 items). Additionally, GMFCS for CP is a level based scale that evaluates patient's self-initiated movements, with emphasis on sitting, moving and walking.

In this study, prior to starting the therapies, GMFM pre-assessment was performed on all participants of different groups namely, RG, IG-A and IG-B. Participants of RG 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 daily as given to RG. After completion of 20 sessions of different therapies (only PT and rTMS+PT) administered to different groups, post-assessment of GMFM was performed. It is to be noted that PT and rTMS sessions were provided 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 GMFM mean scores for each of the three groups were analyzed with a paired-sample t-test, to determine whether any significant differences existed. The variance and covariance analyses were also performed. Additionally, mean and median GMFM scores were used to evaluate the percentage of functional gain that was brought about in different 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 0.001 was considered statistically significant.

Results

The mean, standard deviation (SD), minimum and maximum GMFM scores of pre and post treatment measures for different groups are given in Table 1. The change between the two measurements for different groups is shown in Figure 1.

Group	Min		Max		Median		Mean ± SD	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
RG	5.28	6.27	91.94	92.46	66.54	67.11	52.87 ± 31.51	53.54 ± 31.61
IG-A	3.40	7.00	86.00	88.81	56.78	58.28	48.97 ± 29.74	50.72 ± 29.73
IG-B	3.53	6.27	96.94	98.46	61.45	63.59	48.57 ± 31.37	51.17 ± 31.01

Table 1: Descriptive statistics of reference and interventional groups.

The paired t-test between the pre and post assessment of GMFM scores in reference (only physical therapy) group (RG) revealed significant differences (t=-7.784, df=11, p=0.0001, confidence interval (CI) -0.864 to -0.483). The mean change score was 0.64 (SD 0.29). The paired t-test between pre and post assessment of GMFM scores in interventional (r-TMS +PT) groups were also significant. In IG-A, t= -7.382, df= 14, p<0.0001, CI-2.258 to -1.242 and in IG-B, t= -8.424, df= 13, p<0.0001, CI-3.257 to -1.927. The mean change score was 1.75 (SD 0.92) in IG-A and 2.59 (SD 1.15) in IG-B. Therefore, it can be stated that physical therapy (in RG) and r-TMS followed by PT (in IG-A, IG-B) had a significantly positive effect on the gross motor function in spastic CP children.

Statistical analysis reveal that the improvement in gross motor function for children of interventional group that was administered rTMS pulses was significantly greater than those in reference group. The result confirmed that rTMS combined with PT could cause greater progress in children's motor activity. Additionally, from the mean change scores it was observed that 0.64% progress was obtained following only PT in one month but when rTMS pulses was administered prior to PT, the improvement was appreciable i.e., 1.75% and 2.59% with 5Hz and 10Hz frequency respectively in similar time duration (Figure 2). Also, it was noted that 10Hz r-TMS frequency brought greater improvement as compared to 5Hz as evident from the mean change scores of IG-A and IG-B.

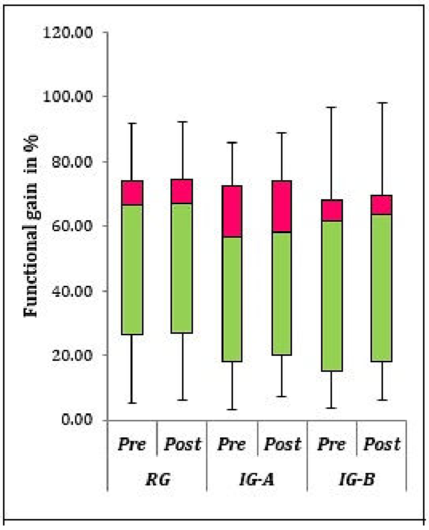


Figure 1: Functional improvement in motor performance of different groups. Shown are median (black center line) and range of functional gain (green and pink).

Discussion and Conclusion

Our study was based on the previous work done employing rTMS by different research groups hat established the fact, if brain stimulation is given repeatedly it can produce lasting changes in brain function with potential therapeutic effects [17,18]. The high frequency rTMS (above 5 Hz to 10 Hz) stimulates the motor cortex area of the brain which facilitates motor function in animals and humans. Recent studies on spinal cord injury (SCI), multiple sclerosis and stroke patients provide good evidence to show the effectiveness of r-TMS on motor function. Kumru et al. study on improvement of motor score and gait pattern demonstrated that high-frequency rTMS combined with rehabilitation therapy can be more effective in the management of motor impairment and spasticity than rehabilitation therapy alone [19]. A similar finding was reported by Elkholy et al. with improved gait patterns in stroke patients [20]. Moreover, Mally and Dinya reported improvement in paretic extremities with rTMS in stroke patients when the traditional rehabilitation had failed [21]. Following evidences from the reported literatures in improvement of motor functions; we conducted this study in spastic CP children to evaluate their motor development. Our findings in the study demonstrate the effectiveness of rTMS in spastic CP cases. Thus, it can be concluded that the administration of high frequency rTMS prior to PT can lead to significant progress in motor function. The improved motor activity in spastic CP children can be attributed to the significant reduction in muscle tightness of both upper and lower extremities due to the stimulating effects of rTMS [22].

Furthermore, the benefit of rTMS demonstrated in our study, provide encouraging results for those who advocate this approach, but we do not consider that the results of this one study should be interpreted as the final answer to the above important question, given that some of the earlier studies have reported weak responses to the TMS therapy. Our research team is working to further evaluate the effectiveness of rTMS using different parameters for different diseased groups in children and also to establish its consistency over a period of time in maintaining the improvement it has induced.

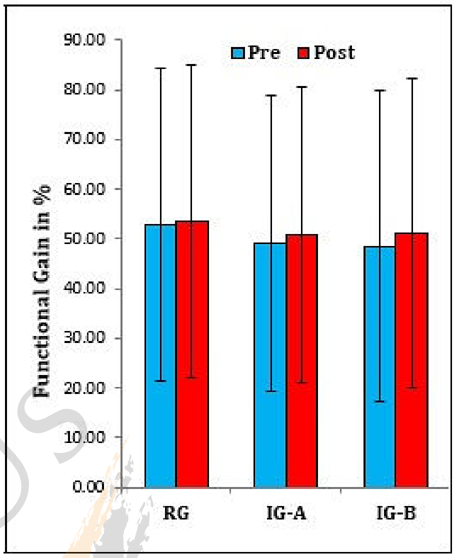


Figure 2: Mean change in GMFM score of different groups between pre-and post-assessment.

Nevertheless, since CP is regarded as heterogeneous spectrum disorder represented by different clinical types, co-morbidities, pathways and genetic variants, it is of much concern that despite different etiological factors contributing to CP causation; there has been little change in the prevalence of this disorder (2-3 per 1000 births) around the world [10]. Thus, the recent research paradigm shifts towards the genetic factor being responsible for CP. A study conducted in 2005, with a four-generation family of nine (9) children that suffered congenital CP, found that a 225 kb deletion on chromosome 9p24.3 might be responsible for the initiation of CP [23]. In addition, ankyrin repeat domain 15 (ANKRD15), the only protein coding gene within this region (chromosome 9p24.3), is interpreted as a maternal imprinted gene, since the healthy fathers of the sick child, who harbor the same deletion, expresses the normal level of this gene. However, no correlation was found between the expression of the ANKRD15 and the pattern of DNA methylation. Traditionally, it is known that DNA methyltransferases (DNMTs) play a key role in the maintenance of imprinted DNA methylation [24]. Interestingly, recent observation indicated that some histone modifiers, such as G9a and GLP, are also involved in the maintenance of genomic imprinting [25]. Therefore, aberrantly established H3K9me2, the G9a/GLP-associated heterochromatin mark, might directly cause abnormal expression of ANKRD15 and lead to initiation of CP in humans. Thus, investigation of the levels of G9a and GLP in patients might shed light towards new direction for the treatment of this neurological disorder.