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THE OUTCOME OF LOWER LIMB STRENGTH TRAINING IN CEREBRAL PALSY CHILDREN WITH SPASTIC DIPLEGIA

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ABSTRACT

OBJECTIVE: To assess the effect of progressive strength training on gross motor function in cerebral palsy children with spastic diplegia in local clinical setup at Lahore Pakistan.

METHODS: This quasi-experimental study was performed in Children Hospital Lahore Pakistan on 45 cerebral palsy patients with Gross Motor Function Classification System (GMFCS) 1-3. Patients were selected through convenient sampling technique. Three sessions of strength training per week for 12 consecutive weeks was given. The resistance was increased according to level of strength of each child calculated by one repetition maximum. Gross Motor Function Measure 88 was used as outcome measure. Pre and post-intervention mean score was compared by using Wilcoxon-signed rank test.

RESULTS: Out of 45 cerebral palsy children, 31 (68.9%) were males and 14 (31.1%) were females. Difference of 4.2 ($p<0.01$) was observed between pre and post-intervention mean score after the 12 weeks strength-training program. There were 17 (37.8%) patients with age < 10 years and 28 (62.2%) patients with ≥ 10 years of age. Out of 45 participants one (2.2%) had a GMFCS score of 1 and 16 (35.6%) had a GMFCS score of 2. Remaining 28 (62.2%) participants had a GMFCS score of 3. P value <0.05 showed that there was significant increase in post training score.

CONCLUSION: Progressive strength training on gross motor function in cerebral palsy children with diplegia is helpful in improving the strength and physical ability of children in our local clinical setup. Improvement was observed more in children aging less than ten years.

KEY WORDS: Cerebral Palsy (MeSH); Muscle Spasticity (MeSH); Resistance Training (MeSH); Spastic Diplegia (MeSH); Gross Motor Function Classification System (Non-MeSH); Lower Extremity (MeSH).

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INTRODUCTION

Cerebral Palsy (CP) is a common cause of physical disability and a major cause of referrals to orthopaedics.[1] There has been a steady increase in the incidence of CP although the neonatal and perinatal mortality rates have decreased.[2]

Brain injury, during, before or after birth, results in CP. The injury to the brain is not progressive resulting in the irregularities of muscle power, tone and movement. The musculoskeletal problem only becomes evident as the child grows the musculoskeletal. Fixed contractures may develop once the child enters the rapid growth period.[1] The occurrence of CP is 2-2.5/ 1000 births which has remained stable over the past 50 years due to the advances in medical technologies.[3]

CP patients shows a heterogeneous population.[4] Spastic type is the most common type of CP5 and are at levels I and II of the Gross Motor Function Classification System (GMFCS).[6,7] Even though school going children with mild CP can walk by their own but their walking ability is not as good as other children of the same age without CP.[8] This trend may get worse with increasing age[9,10] causing the loss of ability of walking.

Diplegia is a disorder characterized by weakness and in coordination of lower limbs with relative sparing of upper extremities.[11] People who have spastic diplegia will usually walk at a slower pace and have difficulty in carrying out tasks such as climbing stairs and running.[12] Most of the children having spastic diplegia will be able to walk in due course but usually at a later age than normal and a flexion moment is present at hip and knee. Due to weakness of ankle plantar flexors and hip and knee extensors the gait pattern of CP child is typical consisting of excessive hip and knee flexion.[13] This gait pattern is called crouch gait.

For the therapy of CP, different intervention strategies are used. Berta and Karl Bobath method of neurodevelopmental treatment is based on hierarchal view of nervous system function. Major component of this technique include techniques and postures which inhibit abnormal reflexes and help in control of muscle tone and observance of normal pattern of motor progression.[14] After participating in exercise regimens CP patients can improve muscle strength, but the changes in function are variable.[15-17] It is difficult to describe the

TABLE I: COMPARISON OF PRE-INTERVENTION AND POST INTERVENTION MEAN OF TOTAL GOAL DIMENSION SCORE OF GROSS MOTOR FUNCTION MEASURE

Position	Pre Mean	Post Mean	Mean Difference	Wilcoxon Signed Ranks Z statistic	p-value
Lying and rolling	99.398	99.564	0.166	-1.342	0.180
Sitting	97.073	98.187	1.114	-2.675	0.007
Crawling	71.606	75.719	4.113	-4.460	0.000
Standing	33.951	42.178	8.227	-5.249	0.000
Walking	20.429	27.830	7.401	-5.069	0.000
Total	64.491	68.696	4.204	-5.520	0.000

TABLE II: COMPARISON OF PRE-INTERVENTION, POST INTERVENTION AND MEAN DIFFERENCE IN GROSS MOTOR FUNCTION MEASURE SCORES

GMFCS# Score	Pre Mean	Post Mean	Mean Difference	Wilcoxon Signed Ranks Z statistic	p-value
1	85.32	85.32	0	There are not enough valid cases for processing in GMFCs score=1.00.	
2	73.12	77.65	4.53	-3.154	0.002
3	58.82	62.98	4.17	-4.623	0.000

#Gross Motor Function Classification System

efficacy of strength training programs in individual with CP because each study include individual with different level of impairments and gait patterns. In addition, most of the studies report average outcomes instead of individual. This makes it hard to understand which subjects benefit from strength training.

Activities of daily life typically involve multi joint movements and are of the closed kinetic chain type. Therefore; a functional strength training program which involves resistance exercises in functional movement patterns has been advocated and has shown effectiveness in improving power and functional activities among CP children.[16]

According to a recent reviews, the limitations in gross motor function among children having CP is caused by the reduced muscle power rather than the spasticity, shifting the focus from management of spasticity to strength training.[18] The strength training program should be individualized according to every child and should incorporate gradual and continuous increase in intensity according to the principle of overload.[19] This is called Progressive resistance exercise (PRE).[20]

For strength training the key principle is the continuous progression of intensity of exercise according to the principle of overload.[21] This is most effectively calculated by repetition maximum (RM) which can be defined as the maximum numbers of repetitions which can be done under a given resistance. One repetition maximum (1RM) is the maximum load in which an individual can perform exercise without any fatigue for one repetition.

According to current guidelines there should be a warm up period of 1-2 sets of 8-10 repetitions with a moderate resistance of 30-60% of 1RM followed by 3-5 sets of 8-15 repetitions with the progression of resistance to 70-85% of 1RM.[22] The frequency of training is recommended to be at least two alternate days per week.

In Pakistan, the concept of strength training is generally overlooked or clinicians have a prejudice for other methods of treatment. By establishing the efficacy of progressive strength training steps could be taken to implement the method in local clinical settings. This study was planned to assess the effect of progressive strength training on gross motor function assess the effect of progressive strength training on gross motor function in cerebral palsy children with spastic diplegia in our set up. A protocol of strength training was devised to increase the strength of lower limb muscles according to the current guidelines for CP individuals.[23] All the variables of training program were standardized including type, frequency, intensity and duration of exercise.

METHODS

This quasi-experimental study was conducted at Children Hospital and Institute of Child Health, Lahore, Pakistan. Duration of research was 6 months after the approval of synopsis. Sample size was 45 with 95% confidence interval according to WHO formula. Non-probability convenient sampling technique was used for sample selection.

Children with spastic diplegia coming to Children Hospital and Institute of Child Health, Lahore, Pakistan were the study population. Children, 8-12 years old, which could follow verbal commands and could walk independently in indoors with or without support, were included in this study. Falls on level 1-3 on Gross Motor Function Classification system was also included in this study. Exclusion Criteria includes any fixed deformity of hip knee or foot; any recent treatment for spasticity; surgery for contractures and seizures. Materials includes Gross motor function classification system (GMFCS), Gross motor function measure 88 (GMFM 88), weight bags, Stepper and ankle weights etc. Data was collected with the help of Gross Motor Function Measure 88 (GMFM 88).

Intervention was consisted of Functional PRE-strength training program of 12 weeks. The program was designed specifically to target the antigravity muscles of the body i.e. glutei, quadriceps femoris and gastrosoleus. Every exercise session consisted of 45-60 minutes along with five minutes warm up and cool down period in which light stretching exercise were performed. During each session every child performed 5 different exercises which included sit to stand, heel raises, forward step ups, sideway

step ups and half knee rise. Three sets of each exercise with 10-15 repetitions were performed with 90 seconds rest between each set. The load was chosen on the basis of individual level of strength of each child which was measured according to 10 repetitions maximum (10 RM). 10 repetition maximum is the maximum weight that can be lifted through 10 repetitions without exhaustion.

For sit to stand the resistance was added through weight vest and high knee rises exercise and by means of ankle weights for forward step ups, lateral step ups and heel raises. Both weight vest and ankle weights were adjustable. The adjustments in weights were made according to individual strength of child.

One examination was made before the start of first session and the next one was made at the end of 12 weeks. The outcome measure was the Gross motor function measure 88 (GMFM 88). GMFM is a standardized assessment tool which measures the variations in Gross motor function of CP child. It needs to demonstrate different motor functions outlined in GMFM administration and scoring guidelines by child. In current work, we were working with the 88 item version of GMFM (GMFM 88) a valid and reliable measure internationally.[24] It has an ICC of 0.93 for inter rater reliability and 0.99 for intra rater reliability.

GMFM consists of five dimensions designated as A, B, C, D, and E. Each dimension tests several activities in one position and the score is rated from 0-3. In which 0 means that the individual cannot start movement and 3 mean that the patient fully completes the movement.

Dimension A measures activities in lying and rolling such as rolling from supine to prone. There are total of 17 activities with a Goal dimension score of 51. Dimension B measures activities in sitting and has a goal dimension score of 60. Dimension C measures activities in crawling and kneeling position and has a goal dimension score of 42. Dimension D measures tasks in standing with a goal dimension score of 39. And finally dimension E measures tasks of walking running and jumping and has a goal dimension score of 72. The final score was calculated by taking the average score of all the dimensions combined.

The independent variable was strength training. The dependent variable was gross motor function measure 88. SPSS version 20 was used for analysis of data. Descriptive statistical analysis and scores will be presented as Mean±SD. Wilcoxon rank test was applied as a statistical tool. Significance level was set at 5%.

RESULTS

Out of 45 CP children, 31 (68.9%) were males and 14 (31.1%) were females. Based on their ages the participants were divided into two groups. One group of age less than 10 years and the second group of participants with age 10 years or more. There were 17 (37.8%) patients with age <10 years and 28 (62.2%) patients with ≥10 years of age. Out of 45 participants 1 had a GMFCS score of 1 and 16 had a GMFCS score of 2. Remaining 28 participants had a GMFCS score of 3 amounting to 62.2% of the total participants.

The final pre-intervention total goal dimension score of GMFM was 64.491 and the post-intervention score was 68.696 with a mean difference of 4.204 and p value of 0.000 showing significant improvement in gross motor function of children with spastic diplegia. The greatest improvement was seen in standing dimension of GMFM with a mean difference of 8.227 followed by walking and running which had a mean difference of 7.401 which correlates with the type of exercises used. Males showed a slightly greater improvement with a mean difference of 4.69 as compared to females which had a mean difference of 3.13. Children belonging to the age group younger than 10 years showed a mean difference of 4.26 while those older than 10 years showed a mean difference of 4.17. So Functional strength training can be used as a standalone or conjunct therapy with other therapeutic techniques to improve the motor skills of children with spastic diplegic CP.

Wilcoxon signed rank test was applied to see the difference between pre-intervention and post intervention mean score of GMFM. The final pre-score total was 64.492 and post score total was 68.696 with mean difference of 4.204 which shows that there was a significant improvement in the post intervention group (Table 1). Wilcoxon signed rank test showed a value of -5.520 with a p value of 0.000 thus rejecting the null hypothesis. The highest mean difference was found in standing with z statistic of -5.249 and p value of 0.000. The smallest difference was found in lying and rolling with z statistic of -1.342 and p value of 0.180.

The greatest change was seen in a group with GMFCS score of 2 with a mean difference of 4.53 between the pre-and post-intervention assessment followed by group with a GMFCS score of 3 with a mean difference of 4.17 between before and after intervention group (Table II).

The result showed a greater improvement in male population with a

TABLE III: GENDER WISE COMPARISON OF PRE- AND POST INTERVENTION GROSS MOTOR FUNCTION MEASURE SCORES

Gender	Pre Mean	Post Mean	Mean Difference	Wilcoxon Signed Ranks Z statistic	p-value
Male	64.64	69.34	4.69	-4.605	0.000
Female	64.14	67.28	3.13	-3.180	0.001

TABLE IV: COMPARISON OF PRE-INTERVENTION AND POST INTERVENTION SCORE OF GROSS MOTOR FUNCTION MEASURE SCORES IN DIFFERENT AGE GROUPS

Age (years)	Pre Mean	Post Mean	Mean Difference	Wilcoxon Signed Ranks Z statistic	p-value
<10	66.97	71.24	4.26	-3.516	0.000
≥10	62.98	67.15	4.17	-4.236	0.000

mean difference of 4.69, Z statistic -4.605 and p value 0.000 as compared to the female population which had a mean difference of 3.13 and p value 0.000 (Table III).

Slightly better progress in the age group of less than ten years with a mean difference of 4.26 as compared to the group of age ten years or more having a mean of 4.17. P value was 0.000 in both groups meaning the change was significant (Table IV).

DISCUSSION

In our study on CP children with diplegia, significant difference in GMFM was observed between pre and post-intervention mean score after the 12 weeks strength-training program.

Previously open chain, single joint and non-weight bearing exercises have been used to strengthen muscles in children with spastic diplegia1 and there has been evidence of improvement in the strength of the muscles, which are targeted, but their effectiveness on motor activity remains controversial and inconsistent. The reason for this might be the fact that single joint and non-weight bearing exercises are not task specific and their transferability to activities of daily life, which are mostly closed chain and multi joint and require a more complex pattern of activation of different muscle groups, is limited. This is called the specificity of strength training program.[25]

Previously it was assumed that resistance training can increase spasticity.[26] But recent studies have shown that resistance exercise can improve power in CP without increasing spasticity. Studies which have observed the effects of function resistance training in children with spastic diplegia have found improvement in muscle strength, physical ability and psychological wellbeing. An RCT found that a home-based strength training program of 6 weeks could show a significant improvement in lower limb muscle strength and could increase the GMFM score of children with spastic diplegia.[27] Another study has shown similar results with a slightly different training regimen but a training duration of 12 weeks.4 New RCTs have been conducted in the recent years to assess the effect of resistance exercise in spastic type CP. They found conflicting results of strength training on strength, gross motor function and walking ability.[21] There is a probability that these inconsistent results are due to difference in methodology but it is more probable that this is due to the different characteristics of exercise training such as type, intensity and duration of training.

The current study results are consistent with previous studies. The children in the previous studies had an age group ranging from 5-12 years[21] and 8-13 years.[4] Even though there is no age limitation for involvement in strength training we recruited children from 8-12 years of age so there was better understanding and comprehension of exercise parameters and exercises could be performed correctly.

Children who were recruited belonged to level 1 to 3 of GMFCS. Only one of the recruited children had a GMFCS score of 1 while majority having a score of 3 as compared to previous studies in which most children had a GMFCS score of 1 or 2.[28] There may be multiple reasons for this scenario. One might be the fact that most children with CP don't get proper treatment and rehabilitation opportunities at the right time or the condition simply goes unnoticed till much later in life when the disability starts worsening and progressing to higher levels of GMFCS.

The exercises selected were of functional patterns which simulated the everyday activities such as heel raises, squats, sit to stand, step ups and leg presses. Functional patterns may exhibit and activity limitation to children having CP with moderate to severe type because of the progression of load and the need to maintain balance and perform the activities as the training progresses. This might be a factor worth considering for developing a training protocol for people with GMFCS score of 3 and above.

Significant changes were found in dimension D (standing) and E (walking) of GMFM consistent with earlier work.[4,17] The results were also consistent regarding the types of exercises performed in the study. We used functional weight bearing exercises targeting the lower limb extensors and ankle plantar flexors which are active in standing walking and running. There is a little possibility of carry over effect to dimension C (crawling) but none to dimension A (lying and rolling). There was no significant change in dimension A which refers to the specificity of training.

The children belonging to younger age group showed a more significant change in total goal dimension score of GMFM than children belonging to older age group. The findings are consistent with previous studies.

The studies have shown positive training results of strengthening exercises on CP child but the results are not convincing. This might be due to the difference in training characteristics or different methods of evaluation. Most of the studies do not describe their training methods in detail thus impeding the correct analysis of results as well as hampering the implementation of intervention in clinical settings. So, it is of utmost importance that all the relevant aspects of intervention and methodology are presented for the future implementation and documentation of protocols.

Besides, almost all the individuals with CP represent a variety of co morbid conditions such as problem with controls, orthopaedic problems and cognitive deficits. There should be a method for the adjustments in training protocols according to every child need.

CONCLUSION

It is concluded from results of our study that progressive strength training on gross motor function in cerebral palsy children with diplegia is helpful in improving the strength and physical ability of children in our local clinical setup. Improvement was observed more in children aging less than ten years, emphasizing more benefit at the younger age.

LIMITATIONS

- There was a limited time frame and resources to complete this study
- The sample size was also less.
- As there is single specialized hospital for children. This study was conducted only on CP children of children hospital Lahore rather than multiple hospitals.

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AUTHORS' CONTRIBUTIONS

Following authors have made substantial contributions to the manuscript as under:

SA & ZM: Conception & study design, acquisition, analysis and interpretation of data, drafting the manuscript, critical review, final approval of the version to be published

MQI: Analysis and interpretation of data, drafting the manuscript, final approval of the version to be published

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

CONFLICT OF INTEREST

Authors declared no conflict of interest

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