Strength training on gait parameters of spastic children

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ABSTRACT
Background of the study: To study the efficacy of “Strength Training” on gait parameters of spastic CP.
Design: Informal experimental design (before and after no control group design).
Setting: Child Development Centre, Valancheri, Kerala.
Participants: Twenty six spastic cerebral palsy children with a mean age of 4.6 years, including nine male and eighteen females were studied for a total duration of eight months. All the children were selected following strict inclusion and exclusion criteria. The study group was a mix of children with crouching, hemiparesis and vertical knee stiffness. Following the baseline evaluation procedures, the children were treated with specially structured Strength Training under the NSCA guidelines. Post intervention data were collected at the end of four months of training.
Outcome measures: Gait speed, one minute walk test, timed up and go test, thirty seconds sit to stand test, ten meter walk test, Community Balance and Mobility scale, “Modified Ashworth Scale”.
Results: The pre and post-test values were treated statistically using SPSS software. Student’s t-test and Wilcoxon signed rank sum test were used to study the significance. An analysis was done to assess the effects of the intervention on subgroups of CP also.
Conclusion: Compound resistance training is effective to improve the gait parameters in spastic cerebral palsy children. Children with crouching demonstrated superior improvements in the gait parameters compared to children with hemiparesis and stiff knee.

Keywords: spastic cerebral palsy, gait parameter, strength training, types of CP gaits

INTRODUCTION
Muscle strength and power are essential components for any individual to perform activities in daily life and to study new functions. Without appropriate muscle strength, it is unable to carry out even the basic motor tasks. Cerebral palsy (CP) is a chronic non progressive neurological condition in which the child characterizes very low muscle strength1,2. Spasticity, impaired motor control, deformed body alignments are few other clinical presentations of CP which vary depending on the severity of the neurological involvement and thereby restricts these children to dependency3.

It was believed that spasticity is the major reason for the limitation of motor functions in CP children and therefore, the therapeutic approaches were focusing only on reducing the spasticity4. However these days there are a lot of research conclusions which have proven resistance training can produce changes in muscle strength of adult spastic conditions like stroke, head injury etc., without decreasing the flexibility5-9. It is believed that, compound resistance training can favor worthy progress in the motor skills, including gait. Many researchers have recommended studying the effect of strength training in spastic CP ambulation9-13.
This study was carried out to analyze the effectiveness of Strength Training on gait parameters in spastic CP. In this paper, we report our observations and conclusions on efficacy of compound resisted exercise on spastics using one minute walk test, ten meter walk test, 30 second sit to stand test, Community Balance and Mobility Scale, speed, Timed Up and Go tests and Modified Ashworth Scale. So this study emphasizes on the resisted exercises which could improve the muscle strength and may provide independency for CP children in performing their daily activities.

MATERIALS AND METHODS
The study design was an informal experimental design (before and after no control). Twenty-seven spastics were included, eighteen females and nine males with a mean age of 4.6 years. The samples were identified from ‘Child Development Centre’, Valancheri, Kerala. The duration of this study was for eight months. Ethical approval was obtained from Nitte University, Mangalore. The inclusion criteria were spastic CPs, GMFCS I – II, 2 – 8 years of age. Any other type of CPs, GMFCS III and above, children with perceptual and cognitive dysfunction, physical deformities, systemic diseases etc. were excluded. Participation consent from each parent was obtained for documentation purpose.

A universally followed pediatric assessment format was used to obtain the outcome measurements. These included the one minute walk test, Community Balance and Mobility test, Timed up and go test, 30-s sit-to-stand test, Modified Ashworth Scale and speed. The subjects were engaged into one month of pre-intervention training as per the NSCA guidelines. The spastic children were receiving Strength Training which included both concentric and eccentric activities like vertical squats, leg press, inclined rowing, sit to stand, half knee rise, step up (lateral/forward), hamstring curls with hip extension and ankle plantar movements, back kicks, resisted diagonal open kinetic movements, resisted bridging, prone aero-plane, cycling, resisted reverse cycling and vertical arching. Free weights, elastic band, tubes and manual resistance were used as the resistors for the open kinetic activities. The therapy included a warm-up period for 5–10 minutes, exercise period of 30–35 minutes and cool-down period of 5 minutes, which altogether lasted 45–60 minutes, given with 40–60% of 1RM on non-consecutive days for 16 weeks. One minute rest between each exercise was allowed as the children senses the first sign of fatigue.

The post intervention data were taken four months later. During the second half of the study, one child with vertical knee stiffness was excluded due to irregular attendance for therapy sessions. Twenty six subjects among the identified samples completed the study, which included nineteen children with crouching, five hemi-paresis and two vertical knee stiffness.

RESULTS
The availed data were analyzed using SPSS-17. The probability value used as the critical value to determine statistical significance was less than 5%.

| Table 1: Demographic data of study participants |
|----------------|----------------|----------------|
|                | Crouch | Hemiparesis | Stiff Knee |
| Mean Age       | 4.8    | 5.2         | 3.1        |
| Male           | 7      | 1           | 1          |
| Female         | 12     | 4           | 2          |
| GMFCS I        | 5      | 3           | 0          |
| GMFCS II       | 11     | 5           | 2          |

All the outcome measures identified for the study were easily administrable without any special training. The average time taken for 1mWT, 10MWT, 30sSST, speed, TUG and MAS were less than 3 minutes whereas CBMS took around 20 minutes.
The mean of pre-intervention and post-intervention data were analyzed using Student’s t-test to identify the efficacy of compound resistance exercises in spastics. The results showed significant improvement in one minute walk test, ten meter walk test, speed, Timed Up and Go tests (p<0.001). (Table 2)

The median of pre-intervention and post-intervention data were analyzed to identify the efficacy of intervention by Wilcoxon Signed Rank Sum Test. The results showed significant improvement in 30 second Sit to Stand and Community Balance and Mobility Scale (Table 3).

Table 3: Comparison of Pre and Post intervention data ‘Wilcoxon Signed Rank Sum Test’

<table>
<thead>
<tr>
<th>Outcome Measures</th>
<th>Significance</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>30s SST in No’s Pre</td>
<td>0.5</td>
<td>.000</td>
</tr>
<tr>
<td>CB&amp;M Post</td>
<td>0.5</td>
<td>.000</td>
</tr>
</tbody>
</table>

Before the intervention, the average gait speed of children with crouching was documented as 0.48m/sec whereas the hemiparesis were .7m/sec. The stiff knee CP had the least walking speed, 0.19m/Sec. Slight improvements were noted following the intervention where the gait velocity were recorded as 0.62, 0.81 and .22 m/sec for crouch, hemiparesis and stiff knee children respectively.

A comparative study on the mean and median values of the intervention outcome measurements were performed between the subgroups. Among the three subgroups of spastic CPs, only crouching had statistically significant improvements compared to others. (Table 4).

Table 4: Comparison between pre and post intervention date between groups

<table>
<thead>
<tr>
<th>Type</th>
<th>Outcome measures (Pre and Post)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crouch</td>
<td>1 MWT</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>10m WT</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>TUG</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>Speed</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>30s SST</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>CB&amp;M</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>1 MWT</td>
<td>.021</td>
</tr>
<tr>
<td></td>
<td>10m WT</td>
<td>.070</td>
</tr>
<tr>
<td></td>
<td>TUG</td>
<td>.178</td>
</tr>
<tr>
<td>Hemiparesis</td>
<td>Speed</td>
<td>.098</td>
</tr>
<tr>
<td></td>
<td>30s SST</td>
<td>.066</td>
</tr>
<tr>
<td></td>
<td>CB&amp;M</td>
<td>.043</td>
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<tr>
<td></td>
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<tr>
<td></td>
<td>10m WT</td>
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<tr>
<td>Stiff Knee</td>
<td>TUG</td>
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<tr>
<td></td>
<td>Speed</td>
<td>.910</td>
</tr>
<tr>
<td></td>
<td>30s SST</td>
<td>.310</td>
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<tr>
<td></td>
<td>CB&amp;M</td>
<td>1.000</td>
</tr>
</tbody>
</table>

DISCUSSION

Gait analysis of children with cerebral palsy demand more concern. Neglecting earlier signs and symptoms of muscular co-activations, inter muscular in-coordination and spasticity can negatively influence their development. There are varieties of freely available clinical evaluation tools for the clinical therapists to assess the status and record the progress of the treatments related to gait.

This study has witnessed the clinical availability of all spastic gait patterns described by Rodda and Graham (2001)\textsuperscript{15}. These include hemiplegia with drop foot, hemiplegia with true equinus gait, hemiplegia with stiff knee gait, hemiplegia with hip flexion gait, true equinus crouch gait, jump gait, apparent equinus gait and crouch gait.
Most spastics were showing marked co-activation of lower limb muscles. This phenomenon was described by Koscielny (2004)\textsuperscript{16}, as “excessive co-activation within and between body-segments could be responsible for at least 3 times higher energy cost for walking in children with cerebral palsy”. It is reported that these co-activation of muscles or abnormal synergies can be reduced by strengthening exercises and thereby reduce the energy expenditure and improve motor control.

In this study, the researcher has observed both male and female children are equally affected with CP. The report from World Health Organization states that cerebral palsy can affect both genders equally.

All children with cerebral palsy had significantly reduced muscle power. Children with CP complain of fatigue at very low intensive activities also. These weaknesses were observed more on the proximal muscles in crouching in contrast to the distal muscular weakness in hemiparesis. There were similar observation reported by Corry et al (1999)\textsuperscript{17}. Rodda and Graham (2001)\textsuperscript{15}.

The age group selected for this study had limitations to perform higher complex exercises compared to many similar studies. However, the interventions were appropriately customized depending on the ability of each child, but without changing the basic principles. The National Strength and Conditioning Association\textsuperscript{14} recommends that there is no minimum age for participating in resistance training, if the participants have emotional and intellectual capacity to follow directs and perform their maximal effort. Rodda and Graham (2001)\textsuperscript{15} in their review of RCTs stated that there is no reason to believe that appropriate age to start progressive resistance exercise training is different in CP.

GMFCS scale was administered to select the subjects for this study since the motor functioning is related to age and severity of CP. The use of GMFCS is recommended by Dodd et al (2003)\textsuperscript{11}. The RCTs by these authors included children classified at GMFCS level I and II, with some classified at GMFCS level III.

The children with crouching had the classical picture of dorsiflexion with hip and knee flexion. The hip flexion is because of weaker Gluteus Maximus, which is a major external rotator when the hip is extended as stated (Delp, Hess et al and Delp, Ringwelski, et al)\textsuperscript{18-20} Also, spastic medial hamstring, iliopsoas muscle or the other adductors are additional contributors to the internal rotation in most of the cerebral palsy clients (Sutherland DH et al\textsuperscript{22} and Chong et al.)\textsuperscript{23}

CPs with crouching were having pseudo adduction, i.e. internal rotation at the hip joint made the limb to appear adducted (Perry - 43)\textsuperscript{22}. Gage (1991)\textsuperscript{23} reported that it is the tensional deformities that shift the direction of muscle action from the normal line of gait progression. There are reports stating that spastic adductors, limb length discrepancy and hip subluxation were observed in the coronal plane. Rodda and Graham (2001)\textsuperscript{23} described that the children with mild coronal and transverse plane issues recovered better may be due to better angle of muscle pull.

The subjects displayed strength gain and better motor skills without observable hypertrophies from the 3\textsuperscript{rd} week of intervention. This achievement are believed to be because of the neural adaptation Le-Mura (2004)\textsuperscript{25} stated that strength gains through resistance exercises in two stages: the first weeks of training remodel the nervous system (motor learning like recruiting the correct
muscles in the proper sequence) and once the “learning” phase begins to diminish, the remodeling of the muscle takes place.

Olaf-Verschuren et al (2011) argues that resistance training involving only multi joint exercise is of limited benefit on strengthening very weak muscles. They recommend single-joint muscle strengthening for very weak muscles.

Spasticity remained more or less unchanged with the intervention in all the three categories of CP. The ROM of hamstrings, adductors muscles: rectus femoris, soleus and gastrocnemius were assessed to confirm the effect of intervention on spasticity. This observation correlated with the reports of earlier studies9-15.

Since there were remarkable clinical recovery in the muscle strength of CP between the age of 2 – 8 without any reported complications and difficulties, we recommended extending the study to a higher age group of children. Also, the relationship between age related musculoskeletal adaptation of CP and effect of compound exercises can be studied further in detail.

Limitations of this study were the presence of disproportional subgroups and the lack of long term follow-ups. Statistics on individual categories of CBMS were also not performed. Further studies can to be done on this.

CONCLUSION

GMFCS is an ideal tool to recruit participants in intervention studies related to CP.

Strength Training is effective to improve gait parameters in spastic CP.

Children with crouching demonstrated superior improvements in gait parameters compared to hemiparesis and stiff knee.

CONFLICT OF INTEREST

None

SOURCE OF FUND

Self

ACKNOWLEDGEMENT

Participants, parents, and team of VKM Child Development Centre, Kerala.

REFERENCES


