EFFECT OF PROGRESSIVE FUNCTIONAL STRENGTH TRAINING FROM PLANTIGRADE FOOT POSITION ON FUNCTIONAL ABILITY IN CHILDREN WITH DIPLEGIC CEREBRAL PALSY

Omnya Samy A. Ghoneim¹, Kamal El Sayed Shoukry², Naglaa A. Zaky³, Hanaa Mohsen Abd-Elfattah⁴
¹Assistant Lecturer, Department of Physical Therapy for Pediatrics and Pediatric Surgery, Faculty of Physical Therapy, Badr University in Cairo, Egypt.
²,³Professor, Department of physical therapy for Pediatrics, Faculty of physical therapy, Cairo University, Egypt.
⁴Lecturer, Department of Physical Therapy for Pediatrics and Pediatric Surgery, Faculty of Physical Therapy, Badr University in Cairo, Egypt.

ABSTRACT

Purpose: The present study aimed to assess the effect of progressive resistive functional strength training from a plantigrade foot position on gross motor function in spastic diplegic children.

Methods: Forty-six children with spastic diplegic cerebral palsy of both genders aged from seven to ten years were randomly allocated into two equal groups; control group (A) and study group (B). These groups were assigned to a designed physical therapy program. Additionally, the study group (B) received progressive resistive functional strength training in the plantigrade foot position. Treatment was conducted for two hours, for three consecutive months, three times a week. Standing and walking (Dimensions D and E) were assessed pre-and post-treatment using the Growth Motor Function Measure Scale (GMFM-66).

Results: post-treatment comparison between both groups revealed that there was a significant improvement in the gross motor function of the study group compared to the control group (p<0.05).

Conclusions: It can be concluded that progressive functional strength training from the plantigrade foot position was an effective program with a higher percentage of improvements in the study group compared with the control group regarding all measured variables.

Keywords: Cerebral palsy, spastic diplegia, functional strength training.

I. INTRODUCTION

Cerebral palsy (CP) is a spectrum of permanent posture and movement impairments resulting in limitation of activity due to non-progressive disorder in the developing fetus or infant brain 1.

Spastic diplegic Cerebral palsy (SDCP) is the most common CP subtype with spasticity as the primary motor disorder. Spasticity results in muscle discomfort, pain, and stiffness, as well as secondary complications that impair function, such as ambulation 2.

According to a recent review, it is inadequate muscle strength, rather than spasticity, that is limiting motor function the most in cerebral palsy children, and this has shifted the focus of care for these children from spasticity management to strength training 3.

Individualized strength training with progressive intensification is necessary to stimulate strength gains more than are associated with normal development and growth. This is referred to as Progressive Resistance Exercise (PRE), which can be performed using any procedure for bearing, overcoming, or resisting force, such as body weight, free weights, or machines 3.
Functional strength training focuses on anti-gravity muscles and is designed to maximize carryover into daily activities. Resistance can be applied in the form of gravity, body weight, resistance bands, or free weights to provide functional strength training. Exercises are designed to target specific muscles or muscle groups recruited during functional activities.

The ability to generate strength is related to motor function, which can be measured using functional scales. The Gross Motor Functional Measure (GMFM) is one of the most commonly used scales, which is used to give a numerical result that corresponds to the patient’s percentage achieved in 88 motor tasks. There have been attempts to determine the relationship between the capacity of generating strength and functional capacity.

The motor function is affected by neuromuscular and musculoskeletal impairments. Lower limb muscle weakness is a common impairment in cerebral palsy children and has been related to walking ability and gross motor function limitations. However, there is little evidence that interventions directed at the impairment levels are effective for rehabilitation. Therefore, the primary goal of the rehabilitation in this study was muscle strength and gross motor function improvement, seeking independence for children with SDCP.

II. METHODS

Study design

The pre and post-experimental design study consisted of two equal groups which were: the study group that received progressive resistive functional strength training from a plantigrade foot position and the control group that received only the designed physical therapy program.

Participants

Sixty-four SDCP children were enrolled for this study. The controlled clinical trial was conducted at the Faculty of Physical Therapy outpatient clinic, Badr University in Cairo and, at the Prof. Dr. Kamal Shoukry pediatric rehabilitation center. Seven children did not fulfill the inclusion requirements, and three children's parents declined to participate. Randomization was conducted by a registration clerk who did not participate in any other aspect of the study. At first, randomization codes were generated using the Microsoft Excel software. The allocation was then concealed in sealed opaque envelopes labeled with sequential numbers. Children meeting the eligibility criteria will then be referred to a researcher who will oversee their treatment and assign them randomly to one of the study groups. The flow chart in Figure 1 illustrates the study design.

Figure 1. Consort Flow Diagram
This randomized controlled study included 46 SDCP children (22 girls and 24 boys). Children were enrolled in this trial based on the following criteria: (1) Children aged 7 to 10 years, (2) Mild spasticity of both lower limbs, grade 1 and 1+ according to the Modified Ashworth Scale, (3) Children were classified to level I, II, and III according to the Gross Motor Function Classification System, (4) Ability to understand and follow instructions.

If a child exhibited any of the following, he or she was excluded from this study: (1) Visual and auditory disorders, (2) Unstable seizures, and (3) Fixed deformities in both lower limbs. The Ethics Review Committee of Cairo University Faculty of Physical Therapy approved this study (NO: P.T.REC/012/002853). The parents of the children signed a written informed consent form consenting to their participation in the study and the publication of the results.

Outcome measures

Gross motor functional measurement (GMFM-66)

The GMFM is a validated scale for monitoring gross motor function changes in cerebral palsy children. Each item on the GMFM is scored on a four-point scale, and the evaluation is divided into five categories: A is for rolling and lying, B is for sitting, C is for crawling and kneeling, D is for standing, and E is for walking, jumping, and running. The outcome measures included the complete dimension D (13 items), which assesses motor skills during standing, and dimension E (24 items), which assesses motor activities during walking, jumping, and running. The results were shown in form of percentages. Higher scores indicate better gross motor capacity measured during a testing session.

Intervention

Each child received the same type of physiotherapy, which consists of stretching exercises (hamstrings, calf, hip flexors, and adductors); strengthening exercises (abdominal and back muscles, hip internal and external rotators, hip extensors, hip flexors, hip abductors, knee flexors, knee extensors, ankle dorsiflexors); kneeling exercises; standing exercises; gait training. The study group received additionally progressive resistive functional strength training from a plantigrade foot position modified from Kannabiran et al., 2016 (Table 1). The child was wearing shoe holders (Figure 2) that keep the feet plantigrade while practicing specific actions designed to increase lower limb strength so the child could not plantarflex and rise on his/her toes.

Figure 2. Shoe holder
The training was completely customized for each child, and exercises were assigned with care to ensure proper execution. Resistance was applied using a customized weight vest during the loaded activities, where functional exercises were conducted. Individual eight-repetition maximum (8 RM) tests were used for determining the training load for the exercises. Regarding GMFCS levels I, II, and III, the predicted 8 RM is approximately 35%, 30%, and 25% respectively of the child's body weight. The load was increased as the child became stronger until all exercises were performed at a maximum of 75% of 8 RM. The selected physical program was given to the control group for 2 hours. The study group had an identical physical program for one hour and a functional training program for one hour, with 90 seconds rest period between each group of exercises three times per week for three consecutive months.

### Sample size

G*Power statistical software was used to calculate sample size (version 3.1.9.2; Franz Faul, Universität Kiel, Germany). (t-tests- Means: Difference between two independent means (two groups), α and β were 0.05 and 0.2, respectively, and large effect size. The appropriate sample size for this study was N= 46.

### Data analysis

To compare subject characteristics between groups, a t-test was utilized. The normal distribution of the data was determined using the Shapiro-Wilk test. To determine group homogeneity, Levene's homogeneity test was used. A paired t-test was used to compare pre-and post-treatment outcomes for both groups to examine each treatment effect. To compare the two groups before and after the intervention, an unpaired t-test was used. The SPSS software version 25 (IBM SPSS, Armonk, NY, USA) was used.

### III. RESULTS

Regarding subject characteristics, the studied groups showed no significant differences (p ≥ 0.05) (Table 2).

A statistically significant improvement (P ≤ 0.05) was observed in both groups when the mean values of all measured variables were compared pre and post-treatment. Regarding all measured variables, the control and study groups showed significant differences, which favored the study group when post-treatment outcomes were compared (P ≤ 0.05) (Table 3).
Table 2. Basic characteristics of participants.

<table>
<thead>
<tr>
<th></th>
<th>Control group</th>
<th>Study group</th>
<th>Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ±SD</td>
<td>Mean ±SD</td>
<td>t-value</td>
</tr>
<tr>
<td>Age (Yrs.)</td>
<td>8.57±1.03</td>
<td>8.43±1.19</td>
<td>0.395</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>26.78±2.33</td>
<td>26.87±2.18</td>
<td>0.131</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>115.65±5.68</td>
<td>117.35±5.22</td>
<td>1.053</td>
</tr>
<tr>
<td>Gender, n(%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Girls</td>
<td>12 (52.2%)</td>
<td>10 (43.5%)</td>
<td>0.384</td>
</tr>
<tr>
<td>Boys</td>
<td>11 (47.8%)</td>
<td>13 (56.5%)</td>
<td></td>
</tr>
</tbody>
</table>

P-value, level of significance; SD, standard deviation; a, t-test; b, chi-square test; n, number; %, percentage

Table 3. Statistical analysis of the dimension D (standing) and E (walking) of a gross motor function measures pre and post-treatment.

<table>
<thead>
<tr>
<th></th>
<th>Pre-treatment</th>
<th>Post-treatment</th>
<th>Pre vs Post</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control group</td>
<td>Study group</td>
<td>P a value</td>
</tr>
<tr>
<td>GMFM-66</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dimension D %</td>
<td>44.22±8.83</td>
<td>51.70±17.87</td>
<td>0.07</td>
</tr>
<tr>
<td>Dimension E %</td>
<td>26.39±7.9</td>
<td>31.26±10.5</td>
<td>0.08</td>
</tr>
</tbody>
</table>

MD, mean difference; SD, standard deviation; a, t-test; %, percentage; P-value, level of significance

IV. DISCUSSION

The current study aims to evaluate the effect of progressive resistive functional strength training from a plantigrade foot position on gross motor function in spastic diplegia children.

The purpose of this study was to conduct a detailed assessment of only dimension D, which assesses motor activities during standing, and dimension E, which assesses motor activities during walking, jumping, and running using GMFM-66. This comes in agreement with Harvey, 2017 10 who stated that the GMFM is a standardized observational instrument used in CP children aged five months to sixteen years for assessing gross motor function. It is frequently used in clinical and research settings to track changes over time or in response to interventions. The mean values of measured variables of pre-treatment data could be supported by the fact that lower limb muscle weakness is a common impairment in CP children and has been associated with difficulties with walking and gross motor function 11.

Concerning the GMFM findings, the results agree with Liao et al., 2007 12 who found a significant effect on GMFM-88 (D & E) and GMFM-66, respectively, after a strengthening intervention program. Similarly, Verschuren et al., 2007 13 reported a significant effect on GMFM D, while Dood et al., 2003 14 reported a significant improvement for GMFM E.

According to Boonyong & Suriyaamarit, 2019 15 SDCP children have muscle weakness, poor balance, poor postural control and alignment, and a lack of muscle coordination. These impairments influence the ability of SDCP children to perform functional activities, particularly standing from a chair or performing the sit-to-stand (STS) task.

Improvements in both groups may be explained by the effect of stretching exercises that were applied to increase soft tissue flexibility by increasing Achilles’ tendon cross-sectional area, increasing, and maintaining hamstring flexibility, which is responsible for active terminal knee extension and may improve walking and crouching posture. These findings are consistent with Ahmadi et al., 2019 16 who stated that muscle stretching could alter muscle structure, irritability, and viscoelastic properties. Spastic muscle stretching is used to normalize tone, improve function, increase soft tissue flexibility, alleviate pain, and maintain and increase the existing range of motion in cerebral palsy children.

www.turkjphysiotherrehabil.org
Higher statistically significant differences in the GMFM in the study group compared with the control group are explained by the plantigrade foot position through the shoe holders while the child practices progressive function strength training as part of weight-bearing and balancing activities. The holder constrains the child’s foot so he cannot plantarflex and rise on his toes, a common problem in SDCP. He can concentrate on flexing and extending his legs to increase strength and limb control. This comes in agreement with Carr & Shepherd, 2010 who reported that, as part of training for weight-bearing and balancing activities, crouching, and standing up can be practiced using shoes attached to a flat surface. In this way, the feet are held with heels on the floor. Once the child gets the idea of pushing down through the feet and flexing and extending the hips, knees, and ankles over the feet, he can practice without shoes.

The findings of the present study confirm those of Kannabiran et al., 2016 who conducted research to evaluate the efficacy of functional strength training in gross motor function improvement in children with SDCP and reported that 15 children aged between 4-6 years were selected and treated with functional strength training. Gross motor function improved after a 12-week functional strength training program.

The computed mean pre-test score of dimension ‘D’ of the control group and study group was 44.22% and 51.70%, respectively, after the pretest assessment was finished. The post-test scores were calculated following the 12-week intervention program, and the mean values for the control and study groups were 56.78% and 67.83%, respectively. In dimension E, the assessed mean pretest score of the control group was 26.39%, and the study group was 31.26%, and the post-test mean score of the control group and study group was 31.74% and 37.91%. As a result of the above findings, we observed significant improvements in the gross motor function following twelve weeks of functional strength training in children with SDCP.

V. CONCLUSION

According to the finding of our study, we can conclude that progressive functional strength training from plantigrade foot position can help children with spastic diplegia improve their gross motor function.

Acknowledgements

The researchers are grateful for all the children's and parents' cooperation and involvement in this research.

Author contribution

Conceptualization: Ghoneim OS, Abd-Elfattah HM, Shoukry KE, Zaky NA. Methodology: Ghoneim OS, Abd-Elfattah HM. Formal analysis: Ghoneim OS. original draft: Abd-Elfattah HM. Approval of final manuscript: all authors.

Conflict of interest

In this research, the researchers state that there is no conflict of interest.

Funding

No special grants were provided for this study by any public, commercial, or non-profit organization.
REFERENCES


