ELBOW ISOKINETIC RATIO AND REACHING ABILITY IN HEMIPARETIC CEREBRAL PALSY CHILDREN

Mostafa S. Ali¹, Shadia Abdelaziz Khalili², Heba Gaber Abd ElAziz¹
¹Lecturer of Physical Therapy for Pediatrics, Faculty of Physical Therapy, Cairo University, Egypt
²Professor of pediatric physical therapy, faculty of physical therapy, October 6 university, vice dean for education and students’ affairs, faculty of physical therapy, October 6 university.

ABSTRACT

Objective: to detect the relation between agonist antagonist ratio of elbow muscles and functional abilities of upper limb in children with hemiparetic cerebral palsy.

Methods: Thirty children with hemiparetic cerebral palsy aged (5-7) years, enrolled from outpatient clinic of Faculty of Physical Therapy, Cairo University and assigned into two groups, control group (A) received designed physical therapy program for one hour while study group (B) received the same designed physical therapy program in addition to strengthening exercise program for triceps brachii muscle for six weeks three sessions per week. The ratio of elbow muscles was evaluated by the biodex isokinetic dynamometer prior and after six weeks of intervention. Functional abilities were evaluated by Peabody Developmental Motor Scale.

Results: There was significant increase (p <0.05) in standard score and significant reduction in extension/flexion ratio (p <0.05) in group (B) more than group (A) but there was non-significant difference in agonist antagonist ratio of elbow muscles with post treatment values of both groups.

Conclusions: balance between agonist and antagonist muscles of elbow joint can maximize muscle strength and improve functional abilities through triceps brachii strengthening program but the ratio has non-significant effect on the functional abilities of the upper limb.

Key Words: Isokinetic ratio, Strengthening program, Reaching ability, Cerebral palsy, Hemiplegia.

I. INTRODUCTION

Cerebral palsy (CP) characterizes as a gathering of postural and development disorders that happen due to a non-progressive insult in the developing fetal or infant brain. The neurological disorders associated with CP are motor impairments; secondary musculoskeletal disturbances, pain, and fatigue leading to alterations of motor functions in children and adults with CP that may result in inability to walk [1]. CP is one of essential childhood disability that disturb the child health in several directions; primary neuromuscular disorders, such as spasticity, diminished motor control of certain groups and muscle weakness, and associated musculoskeletal problems, such as contractures and bony deformities. Also, perception, behavior, cognition and communication are disturbed in children with CP [2].

Hemiplegic kind of cerebral paralysis is the most widely recognized structure with pervasiveness 1/1000 of live births [3]. Children with spastic hemiplegia walk independently but have several variations of affected arm and hand functions [4]. Children with Hemiparesis have mobility dysfunctions due to muscle weakness, loss of selective motor control and reduced balance and diminished gait parameters [5, 6]. Muscle shortcoming is one of the most perceptible worries of hemiplegia [7-9].

The basic neuromuscular mechanisms of hemiparesis comprise disturbance of motor units’ function [10], alterations in order of motor recruitment [11] and diminished the firing rates of motor units [12-15]. Movement is a complex motor performance needing neuronal co-ordination and harmonization of muscle synergies through muscles of the limb [16]. Adequate strength is needed to initiate grasp patterns with different types and continue during carrying. Children with reduced strength have problem to initiate the finger extension or the thumb

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opposition pattern that required for grasp, also might loss the flexor control to hold a grasp pattern [17]. Muscle synergy is the mutual effect of two muscles or more that exceeds the sum of their individual effect [18].

In current study, the children perform reaching to detect muscle activations as reaching was widely considered in normal humans in addition to long-lasting paralysis of one side to recognize well upper limb movement control [19, 20]. Resistance exercise program can be performed either dynamic or static muscle contractions aiming to improve physical function through the development of maximal muscular strength, power and endurance [21]. The evaluation of muscular strength is a key element in the assessment of children with neurological disorders [8]. Weakness may be measured accurately with cumulative availability of sophisticated computer interfaced equipment [9] so, isokinetic dynamometers was used in clinical and laboratory setting as one of the various types of strength testing equipment [22, 23].

We conducted a randomized controlled trial of 6 weeks duration to investigate the relation between agonist antagonist ratio of elbow muscles and functional abilities of upper limb in children with hemiparetic cerebral palsy. The main hypothesis was that there is a relation between agonist antagonist ratio of elbow muscles and functional abilities in children with hemiparetic cerebral palsy.

II. MATERIAL AND METHODS

Study design

a randomized pre-post, controlled trial. It has been approved by the ethical committee at the Faculty of Physical Therapy, Cairo University.

Participants

Thirty children with hemiparetic cerebral palsy of both sexes were enrolled from outpatient clinic of Faculty of Physical therapy, Cairo University. They were enrolled and assessed for their eligibility to participate in the study. Inclusion criterion included children that diagnosed as hemiparetic cerebral palsy, able to sit, also their age ranged from 5 to 7 years and their degree of spasticity ranged from 1 to +1 according to the Modified Ashworth Scale [24]. Exclusion criterion of this study included Children who had visual and auditory defects that affect their performance, convulsions, fixed contractures and surgical interventions in the upper extremities. Informed consent has been obtained from the parents of all individuals included in this study.

Randomization

Previously, four participants were excluded, as two do upper limb operations and another two withdraw from the study (Figure 1). After that the authors make direction meeting about the examination, at that point arbitrarily separated into two equivalent groups by a blinded and a free exploration aide who opened fixed envelopes that contained a PC produced randomization card. No subjects dropped out of the study after randomization.

III. MEASUREMENT PROCEDURES

Biodex Isokinetic Dynamometer: It was used for measuring agonist antagonist ratio of elbow muscles in the affected upper limb. Test Procedures were started with collection of personal data (name, age, address and telephone number) [25]. Then, Instructions of test were conducted for each child before applying the procedures. Many individuals who would experience strength testing may have little or no experience to perform the test maneuvers. So the children must be instructed the purpose and intention of the test. An informed child will be less fearful and will provide more reliable test efforts [25]. The child sit with the back erect and asked to perform elbow extension and the ratio of agonist antagonist ratio of elbow muscles is recorded on the computer.

Peabody Developmental Motor Scale: assessment of the reaching children with hemiparetic cerebral palsy was done for every child in two groups’ pre and post six weeks of intervention by the Peabody Developmental Motor Scale (PDMS-2). The child sits in a relaxed position and orients him with the test procedures. The evaluator seated beside or in opposite to the child. Only single material should be on the table and other should be away from the child’s view. The PDMS-2 is based on scoring each item as 2, 1, and 0. The evaluator must select how to score the item based on his / her judgment of the child’s performance and specific criteria for each item Test Administration: The entry points, basal and ceilings were used on visual motor integration. Entry points: The entry points were marked on visual motor integration in the examiner record booklet. They were resolved exactly to permit the analyst to being testing on an item that 75% of children in the normative sample at that age passed.
The examiner should use clinical judgment to determine the most appropriate entry point; i.e., that testing should begin with items on which the child can be successful. **Basal level:** The basal was set up when the child gets a score of two on three successive items in a row. The last three 2s before the one or zero became the basal level. **Ceiling level:** When basal was set up, the inspector regulated continuously more troublesome things until a ceiling was built up when the child scores zero on each of three items in a row; then the testing was discontinued. **Record of Scores:** After organization of all tests in visual motor integration, raw and standard scores were determined. **Raw Scores:** Raw scores were the all-out focuses amassed by a child on each subtest (kid got a 2, 1, or 0 for every item). They were recorded first before the other scores. **Standard Scores:** Standard scores provide the clearest picture of an examinee’s subtest performance. Standard score of each subtest was converted from raw scores of this subtest [26].

**IV. TREATMENT PROCEDURES**

Children in both groups received a specially designed 60 min physical therapy exercise program with a certain modification according to the needs of the child. It included the following (Bobath technique, Facilitation of fine motor skills, strengthening exercises for the intrinsic muscles of the hand, Facilitation of postural mechanisms, Proprioceptive training, Gait training and Stretching exercises). The study group received manual resistance exercise and mechanical resistance exercise (By using biodex isokinetic dynamometer) for triceps brachii muscle three times per week, for six weeks in addition to the designed physical therapy program given to the control group.

**Manual resistance exercise:**

Manual resistance exercise is a form of active exercise in which resistance is provided by therapist. This technique is beneficial in the early stages of an exercise program when the muscle to be strengthened is weak and can only overcome mild to moderate resistance. The amount of resistance given is limited only by the strength of the therapist in form of three sets each set consist of ten repetitions with a period of rest between each set from different positions [27].

**Mechanical resistance exercise**

The patients educated regarding isokinetic resistance and the overall procedures, performed warm up exercises before starting, placed in a comfortable sitting position. shoulder, waist and thighs were stabilized, hand grip rotated to work on elbow extensors, performed 3 repetitions at first to become accustomed to the device, movement was at level of extension and speed at level of 120/s and then progress to 180/s and patient performed three sets each set contains eight repetitions for 3 days per week for six weeks.

**Sample size**

Sample size estimation was performed preceding the investigation utilizing G*POWER statistical programming (version 3.1.9.2; Franz Faul, Universitat Kiel, Germany) [power (1−α error P) = 0.85, α = 0.05, effect size = 1.1, with a two-tailed for a comparison of 2 independent groups] determined a sample size of 15 for each group in this study (figure 2). This effect size was calculated according after a pilot study on 10 participants (5 in each group) considering Extension/flexion isokinetic ratio as a primary outcome.

**Data analysis**

All statistical measures were performed using the Statistical Package for Social science (SPSS) program version 23 for windows. There was a linear relationship between the dependent variables, as assessed by scatterplot, and no evidence of multicollinearity, as assessed by Pearson correlation (|r| < 0.9). There were no univariate outliers in the data, as assessed by inspection of a boxplot, and no multivariate outliers in the data, as assessed by Mahalanobis distance, standard score and extension/flexion ratio were normally distributed, as assessed by Shapiro-Wilk's test (p > .05). There was homogeneity of variances, as assessed by Levene's (p > .05) for all dependent variables. So, 2x2 mixed design MANOVA was used to compare the tested variables of interest at different tested groups and measuring periods. The alpha level was set at 0.05.

**V. RESULTS**

A total of 30 participants were included in the final data analysis. They were divided into two groups; group A consisted of 15 patients receiving designed physical therapy program in addition to strengthening of triceps brachii muscle, and the group A consisted of 15 patients receiving designed physical therapy program only. The
independent t test revealed that there were no significant differences (p>0.05) in the mean values of age, body mass and height between both tested groups (table 1).

Statistical analysis using mixed design MANOVA analyzed thirty patients assigned into two equal groups. It revealed that there were significant within subject effect (F = 329.785, p = 0.0001) and treatment*time effect (F = 87.482, p = 0.0001). While there was significant between subject effect (F= 7.623, p = 0.001). Table (2) present descriptive statistic (mean ± SD) and multiple pairwise comparison tests (Post hoc tests) for the all dependent variables. In the same context regarding within subject effect, the multiple pairwise comparison tests revealed that there was significant increase (p <0.05) in standard score and significant reduction in extension/flexion ratio (p <0.05) in favor to group

VI. DISCUSSION

This study was conducted to determine the relation between agonist antagonist ratio of elbow muscles and functional abilities of upper limb in children with hemiparetic cerebral palsy as limited data exists concerning the correlation between isokinetic testing of hemiparetic patients and functional performance tests. Results revealed that regarding between subject effects multiple pairwise comparisons there was significant increase (p <0.05) in standard score and significant reduction in extension/flexion ratio (p <0.05) in favor to group B than group A but between both groups there was non-significant difference in agonist antagonist ratio of elbow muscles.

However, the significant improvement obtained in the post treatment mean values of the measured variables especially for the study group may be attributed to strengthening exercise of triceps brachii muscle. Significant improvements in all measuring variables of study group are consistent with Smith who confirmed that resistance program for many repetitions improve muscle strength [28]. Also Tax confirmed the results of current study who stated that strengthening program of a certain muscles improve power as well as the power of the muscles acting in the same group or same limb and have the same synergies acting on a certain movement [29].

The results of the current study were reinforced by those of Eccles, who concluded that muscular strength is essential for efficient movement and stability of the joints that reduce the risk of musculoskeletal injuries in addition to performing activities of daily living without fatigue [30]. A study was performed on patient with C5 and C6 quadriplegics using functional neuromuscular electrical stimulation to improve wrist extension demonstrated that subjects were able to reach and grasp objects in space which were unachievable in space without triceps activation [31].

The results of previous study that applied on forty-five healthy adults to study the ideal position of the elbow when measuring peak grip strength agree with our results as grip strength endurance can be achieved in ninety-degree flexion or full extension of the elbow [32]. The improvement of functional abilities of upper extremity is reinforced by the results of previous study conducted on twenty-two hemiplegic patients to determine the effect of neuromuscular electrical stimulation on upper limb function and hand sensation that included activation of triceps brachii to improve elbow extension which concluded that the program gain more functional arm movement activation of triceps brachii that essential to perform elbow extension and improve hand sensation [33]. Muscle strength of the affected extremities of hemiparetic children is measurable with reliability even with mild spasticity [34]. Relationships between changes in muscle activation and changes in reaching performance allow us to explore how different characteristics of muscle activation may influence different characteristics of movement performance. The improvement in muscle strength and the decrease in the level of agonist antagonist ratio may underline improved reaching performance in those children [35]. Improving reaching ability through strengthening program can be explained as spasticity of unilateral side demands excessive effort to move as the normal power values is completely consistent with total work and peak torque values [35].

Results of this study come in agreement with a study found that all patients have voluntary knee extension moment of the affected limb although presence of mild spasticity in the affected knee extensors. Therefore, paretic muscle with mild spasticity that preserves the ability to perform significant amount of muscle strength have a non-significant effect on the consistency of torque production [36] which may explain why there was no difference in agonist antagonist ratio despite the improvement in the functional ability (reaching) of the upper limb. Results of previous study showed non-significant relation of flexors/extensors peak torque ratio in the affected and unaffected
side during different types of action [36]. This can be explained as the basic neuromuscular mechanisms of hemiparesis comprise disturbance of motor units’ function, alterations in order of motor recruitment and diminished the firing rates of motor units [10-12].

The finding that the agonist antagonist ratio of the two gathering groups was not significantly different demonstrates that strength losses because of changed joint movement elements, deficiency in the muscles themselves or the neural control mechanism or may be due to all of them.

**Study limitations**

In terms of the study limitations, there was no follow-up period, so the long-term effect of the training in children with hemiplegic cerebral palsy cannot be detected.

**VII. CONCLUSION**

Strengthening program of triceps brachii muscle can balance between agonist and antagonist muscles of elbow joint and to obtain efficient muscle strength and maximal functional abilities however the ratio has non-significant effect on the functional abilities of the upper limb.

**Source of funding**

This study did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

**Conflict of interest**

The authors have no conflicts of interest to declare.

**Ethical approval**

This study was approved by the Ethical Committee faculty of physical therapy, Cairo University (NO: P.T.REC/012/002550) on 1 December 2019.

**Authors’ contributions**

The authors testify that all persons designated as authors qualify for authorship. MSM was involved in the study concept and design, interpretation of data, and writing of the initial and final drafts of the article. SAK and HGA were involved in data acquisition and analysis. All authors have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

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**REFERENCES**


<table>
<thead>
<tr>
<th>Items</th>
<th>Group A</th>
<th>Group B</th>
<th>Comparison</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>5.8±0.5</td>
<td>5.9±0.7</td>
<td>740.47740</td>
<td>0.85</td>
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<tr>
<td>Body mass (kg)</td>
<td>21.13±2.34</td>
<td>21.7±2.46</td>
<td>-0.91</td>
<td>0.36</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>120.33±3.93</td>
<td>119.66±6.3</td>
<td>0.49</td>
<td>0.62</td>
</tr>
</tbody>
</table>

*SD: standard deviation, P: probability, S: significance, NS: non-significant.
Table (2): Descriptive statistics and multiple pairwise comparison tests (Post hoc tests) for the all dependent variables for both groups at different measuring periods

<table>
<thead>
<tr>
<th>Variables</th>
<th>Group B</th>
<th>Group A</th>
</tr>
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<tbody>
<tr>
<td>Standard score</td>
<td>Pre: 2.6±0.73</td>
<td>Pre: 2.26±0.79</td>
</tr>
<tr>
<td></td>
<td>Post: 6.66±1.23</td>
<td>Post: 4±0.75</td>
</tr>
<tr>
<td>Extension/flexion isokinetic ratio</td>
<td>Pre: 2.02±0.31</td>
<td>Pre: 1.9±0.41</td>
</tr>
<tr>
<td></td>
<td>Post: 1.52±0.35</td>
<td>Post: 1.78±0.39</td>
</tr>
</tbody>
</table>

**Within groups (Pre Vs. post)**

<table>
<thead>
<tr>
<th>p-value</th>
<th>Standard score</th>
<th>Extension/flexion isokinetic ratio</th>
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</thead>
<tbody>
<tr>
<td>Group A</td>
<td>0.0001*</td>
<td>0.0001*</td>
</tr>
<tr>
<td>Group B</td>
<td>0.0001*</td>
<td>0.035*</td>
</tr>
</tbody>
</table>

**Between groups (group A Vs. group B)**

<table>
<thead>
<tr>
<th>Pre treatment</th>
<th>Standard score</th>
<th>Extension/flexion isokinetic ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.245</td>
<td>0.379</td>
</tr>
<tr>
<td>Post treatment</td>
<td>0.0001*</td>
<td>0.066</td>
</tr>
</tbody>
</table>

*Significant at the alpha level (p < 0.05).
Figure (2): Plot of sample size calculation.