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Research Article

Relation Between Core-Stability and Functional Abilities in Children with Spastic Cerebral Palsy

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Abstract

Attention has been given recently to gain insight about abnormal movements that are present in spastic CP that related to one's level of core stability and how it affects functional abilities. The purposes of this study were to investigate of core stability affection in children with spastic cerebral palsy and to determine the relationship between core stability and functional abilities in children with spastic cerebral palsy. Seventy five children participated in this study divided into twenty five normal healthy children included in group A. Fifty children of spastic CP with level I and II of Gross Motor Function Classification System (GMFCS), spasticity grade 1 and 1^+ and their age ranged from six to ten years. Children were divided into two groups; group B consisted of twenty five children with spastic diplegic while group C consisted of twenty five children with spastic hemiplegia. Each child in the three groups was evaluated by using gross motor function measure and biodex isokinetic dynamometer to assess trunk flexors and extensors peak torques. The results revealed significant differences in the trunk flexors and extensors peak torque at angular velocity 120rad sec^{-1} between group B and group C in favor of group C and the peak torques was higher in Group A when compared to both groups B and C. This study concluded that the children with spastic cerebral palsy either hemiplegic or diplegic have poor core stability and the correlation between core stability and GMFM of all participants was significant.

Key words: Core stability, gross motor function, spastic cerebral palsy

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Cerebral Palsy (CP) describes a group of permanent disorders of the development of movement and posture, causing activity limitation, that are attributed to non-progressive disturbances that occurred in the developing fetal or infant brain. The motor disorders of cerebral palsy are often accompanied by disturbances of sensation, perception, cognition, communication, behavior, epilepsy and secondary musculoskeletal problems (Rosenbaum *et al*., 2007).

Despite ongoing debate regarding the contribution of the primary impairments muscle weakness versus spasticity to the motor dysfunction seen in CP. Musculoskeletal researchers have increasingly recognized and described the importance of the trunk muscles as core stabilizers in lower limb function (Tilton, 2009).

Core stability is the ability to control the position and motion of the trunk over the pelvis to allow optimal production, transfer and control of force and motion to the terminal segment. Core stability is necessary to help maintain a good posture and give a stable base to allow the arms, legs and head to move in a coordinated manner (Kibler *et al*., 2006).

Functional movement is the ability to produce and maintain a balance between mobility and stability along the kinetic chain while performing fundamental patterns with accuracy and efficiency. Muscular strength, endurance, coordination, balance and movement efficiency are components necessary to achieve functional movement, which is integral to performance gross motor skills (Mills *et al*., 2005).

The sequence of muscle activation during whole body movements was studied and it was found that some of the core stabilizers (i.e., transversus abdominis, multifidus, rectus abdominis and oblique abdominals) were consistently activated before any limb movements. These findings support the theory that movement control and stability are developed in a core-to-extremity (proximal-distal) and a cephalo-caudal progression (head-to-toe) (Hodges, 2003).

Several methods are available for testing trunk muscle strength. These include manual muscle testing and dynamometry. Dynamometry includes the use of handheld dynamometers, handgrip dynamometers and isokinetic dynamometers (Sisto and Dyson-Hudson, 2007). In the clinical settings, the standard method of measuring core strength and endurance is through the use of isokinetic dynamometers (Keller *et al*., 2001; Karatas *et al*., 2002).

Recently, attention has been given to gain insight about abnormal movements that are present in spastic CP that related to one's level of core stability and how it impacts functional abilities. So the aim of this study was to investigate if core stability is affected in children with spastic CP and to determine the relationship between core stability and functional abilities in children with spastic CP.

MATERIALS AND METHODS

Seventy five children of both sexes were recruited form the Out-Patient Clinic Faculty of physical therapy, Cairo University and participated in this study. Agreement of the Ethical Committee of Faculty of physical therapy was obtained before beginning of the study. Children were selected according to the following criteria:

Inclusion criteria of the study group:

- Children age ranged between six to ten years as it may be difficult to measure muscle strength in very young children
- Their height more than one meter to allow optimum calibration with isokinetic dynamometer
- Children were classified at level I and II by gross motor function classification system selected (GMFCS)
- Children with spasticity ranged from grade 1-1^{+} according to modified ashwarth scale (Bohannon and Smith, 1987)
- Able to follow orders and verbal commands
- Participant did not have any specific core stability training for at least six month

Exclusion criteria of the study:

- Children with congenital cardiorespiratory condition, behavior disorders like autism and visual and hearing disabilities were excluded
- Uncontrolled seizures
- Children with fixed musculoskeletal deformities of axial part

Design: All children are divided into three groups of equal number (25 in each) using observational study:

- **Group (A):** Twenty five normal healthy children (9 girls and 16 boys). Their Mean±SD of age, weight and height were 9±1.36 years, 23.4±4.38 kg and 121±6.89 cm, respectively

- **Group (B):** Twenty five children (11 girls and 14 boys) with spastic diplegic. Their Mean±SD of age, weight and height were 8.28±1.68 years, 24.13±4.51 kg and 120±9.72 cm, respectively
- **Group (C):** Twenty five children (10 girls and 15 boys) with spastic hemiplegia. Their Mean±SD of age, weight and height were 8.14±1.49 years, 24.93±5.88 kg and 122.06±11.04 cm, respectively

Instrumentation for assessment:

- Biodex Isokinetic System which measures the internal torque produced by trunk flexors and extensors while the trunk is maintaining angular velocity of 120rad sec^{-1} and same range of motion
- Gross motor function measure scale (GMFM-88) was used to measure function abilities in kneeling, standing and walking dimensions

Procedure: The procedure is divided into two steps; first step was related to assessing the isokinetic parameters as a reference to core muscle strength through the use of Biodex Isokinetic system. The second step was related to the use of GMFM of Children in kneeling, standing and walking dimensions to reflect the degree of functional limitation.

First step in procedure:

- The personal data of the child were collected from parents. The data included the child name, age, weight and height
- A brief orientation about the nature of the study, its aims and the tests to be accomplished was provided to care givers
- The child was allowed to sit on the adjustable seat of the Biodex Isokinetic Dynamometer system. The sitting position was reported to be the optimal resting position being more tolerated than the standing one. It allows greater range of motion both in flexion and extension and hence is the preferred testing position (Dvir and Keating, 2001)
- The pelvic strap was then applied and positioned as far as possible to press firmly, but comfortably, against the superior aspect of the proximal thighs. Two curved anterior leg pads were secured to adjust the knee block position. In addition, a lumbar support pad was located against the lower lumbar spine. Therefore, the pelvis was stabilized to minimize any contribution from the hip muscles (Dvir and Keating, 2001). Both thighs were then stabilized by two straps and the feet were held in place without being in contact with the floor
- The child sat erect with the head stabilized neutrally against an adjustable head seat. The two anterior force application straps were aligned vertically and then connected to another horizontal strap which was aligned with the second inter-costal cartilage on the anterior chest wall when measuring the flexion torque. The posterior force application padded roller bar was placed on the posterior trunk just distal to the spine of the scapula when measuring the extension torque
- To prevent any jerky movement from the arms, the child was instructed to rest his/her crossed forearms on the anterior chest wall. In addition, the child was requested to maintain a neutral head position throughout the testing procedure to avoid any contribution from the neck muscles (Shirado *et al*., 1995)
- The tested trunk ROM for each child was determined by allowing the tested participant to flex his/her trunk 50° from the vertical position. The position was confirmed with a protractor situated at the side of the testing chair. The set limit button was then pressed to lock the ROM for this direction. The participant was then asked to extend his/her trunk 20° from the vertical position and the set limit button was pressed again to lock the ROM for this direction. Thus, the isokinetic testing procedures were conducted at a ROM of 70°
- Before the actual isokinetic testing procedures, each child performed one practice series of three sub-maximal trunk extension and flexion repetitions to get accommodated with the specificity of the Biodex speed of movement and trunk ROM. That was done to minimize any mistakes during the actual testing procedure
- Each practice session involved performing five consecutive trunk flexion-extension repetitions and the participant was instructed to push and pull as hard and as fast as possible
- Verbal encouragement was given during the testing procedure to maximize the child participation
- Trunk extensors and flexors were tested at the concentric mode of muscle contraction

Second step in procedure

Assessment of gross motor function abilities: The motor function of all children was examined by GMFM-88 which is an evaluative index of gross motor abilities and change in function over time or after therapy specifically for children with CP. It designs to asses function in quantitative manner without regard to the quality of performance.

Statistical analysis: Statistical analysis of the data was performed using SPSS software for medical statistics. The significance level was set at $p<0.05$.

RESULTS

Comparison of trunk flexors peak torque at $120°sec^{-1}$ between group A, B and C showed a significant difference in trunk flexors peak torque at 120º sec^{-1} between the three groups (p = 0.0001) (Table 1).

The mean difference in trunk flexors peak torque between group C and B was 15.59 Nm. There was a significant increase in trunk flexors peak torque in group C compared with group B (p = 0.0001). The mean difference in trunk flexors peak torque between group A and C was -14.33 Nm. There was a significant increase in trunk flexors peak torque in group A compared with group C (p = 0.001). The mean difference in trunk flexors peak torque between group B and A was -29.92 Nm. There was a significant increase in trunk flexors peak torque in group A compared with group B (p = 0.0001) (Table 1).

Comparison of trunk extensors peak torque at $120°sec^{-1}$ between group A, B and C showed a significant difference in trunk extensors peak torque at $120°sec^{-1}$ between the three groups (p = 0.0001) (Table 2).

The mean difference in trunk extensors peak torque between group C and B was 19.56 Nm. There was a significant increase in trunk extensors peak torque in group C compared with group B (p = 0.0001). The mean difference in trunk extensors peak torque between group A and C was -1.24 Nm. There was no significant difference in trunk extensors peak torque between group A and C (p = 1). The mean difference in trunk extensors peak torque between group B and A was -20.8 Nm. There was a significant increase in trunk extensors peak torque in group A compared with group B (p = 0.0001).

Comparison of total GMFM between group A, B and C: The median total GMFM of group A, B and C were 153, 111 and 140, respectively. There was a significant difference in median GMFM knelling between the three groups (p = 0.0001).

There was a significant increase in median value of total GMFM of group C compared with group B (p = 0.0001). There was a significant increase in median value of total GMFM of group A compared with group C (p = 0.0001). There was a significant increase in median value of total GMFM of group A compared with group B (p = 0.0001).

Relationship between core stability and functional abilities: The correlations between trunk flexors peak torque at 120º sec^{-1} and total GMFM were moderate positive significant correlation (r = 0.46, p = 0.01) while the correlations between trunk extensors peak torque at 120º sec^{-1} and total GMFM were moderate positive significant correlation (r = 0.65, p = 0.0001).

Table 1: One way ANOVA for comparison of trunk flexors peak torque at 120rad sec^{-1} between groups A, B and C

$\bar{X}\pm SD$					
Group A	Group B	Group C	F-value	p-value	Significance
Trunk flexors peak torque (Nm) at 120º sec^{-1}					
61.12±7.61	31.2±11.04	46.79±10.23	35.38	0.0001	S

Groups	MD	p-value	Significance
Multiple comparison (bonferroni correction)			
Group C-B	15.59	0.0001	S
Group A-C	-14.33	0.001	S
Group A-B	-29.92	0.0001	S

$\bar{X}$: Mean, SD: Standard Deviation, MD: Mean difference, p-value: Probability value, S: Significant

Table 2: One way ANOVA for comparison of trunk extensors peak torque at 120rad sec^{-1} between groups A, B and C

$\bar{X}\pm SD$					
Group A	Group B	Group C	F-value	p-value	Significance
Trunk extensors peak torque (Nm) at 120° sec^{-1}					
67.82±11.55	47.02±7.69	66.58±8.54	23.07	0.0001	S

Groups	MD	p-value	Significance
Multiple comparison (bonferroni correction)			
Group C-B	19.56	0.0001	S
Group A-C	-1.24	1	NS
Group A-B	-20.80	0.0001	S

$\bar{X}$: Mean, SD: Standard Deviation, MD: Mean difference, p-value: Probability value, S: Significant, NS: Non significant

DISCUSSION

The previous study focused on the core stability affection in children with spastic cerebral palsy either hemiplegic or diplegic compared to normal age population and to determine the relationship between core stability and functional abilities in children with spastic cerebral palsy.

The results of the current study showed significant differences in the trunk flexors and extensors peak torque at angular velocity 120rad sec^{-1} between group B and group C which indicate the strength of trunk muscle of hemiplegic group is higher than diplegic group. On the other hand the trunk flexors peak torque and trunk extensors peak torque at same angular velocity were higher in group A: the typical development children when compared to group B and C. This agrees with Scianni *et al*. (2009) opinions who report that trunk muscle weakness is a common disorder in children with CP and is associated with insufficient or reduced motor unit discharge when compared with children of typical development.

This also agrees with Heyrman *et al*. (2013) who found that the children with hemiplegia obtained the highest scores of Total Trunk Control Measure Scale (TCMS), followed by children with diplegic and children with quadriplegia obtained the lowest scores. The TCMS scores were significantly decreased with increasing GMFCS level. They concluded that, trunk control is impaired in children with CP to a various extent, depending on the topography and severity of the motor impairment. The findings of the current study also provide specific clues for treatment interventions targeting trunk control to improve their functional abilities.

The gross motor function abilities of all participants in the current study were measured by GMFM. The result of the current study showed that there was a significant increase of GMFM median value of group C compared to group B. that mean the motor abilities of hemiplegic type is much more higher than diplegic type in the same age period and same GMFCS. While the GMFM median value of group A is higher than in group B and C which indicated that the gross motor function of spastic cerebral palsy children either hemiplegic or diplegic is much less than the function abilities of children with typical development.

Children with spastic CP who participated in this study showed defect in GMFM score which comes on agreement with Prosser *et al*. (2010) who reported that young children with CP demonstrates excessive, non-reciprocal trunk and hip muscle activation during walking compared with children with typical developed children.

The result of this study also showed the correlation between trunk flexors and extensors peak torque at angular velocity 120rad sec^{-1} and GMFM of all participants was significant.

The current study correlations agrees with the result of Ross and Engsberg (2007), who reported that muscle strength was highly related to gross motor function and moderately related to gait. The results are in agreement with the recent literature indicating a positive significant correlation between strength and gait and function in persons with CP (Nudo, 2003; Lauer *et al*., 2007).

This correlation of this study meets the provisions of the International Classification of Functioning, Disability and Health (ICF), which defines the health status of individuals as multi-directional relationships between different domains of health. Accordingly, changes in body structure and function (such as deficits in core stability as observed in CP) are related to the level of activity and functional participation. Therefore, the poor core stability might correlate with a child's reduced performance in functional abilities and lower level of gross motor abilities (Dos Santos *et al*., 2012).

The findings in our study were related to the finding of Andersson *et al*. (2003) who showed that a 10-week progressive strength training program focused on the lower extremities improves walking ability. Results show significant improvements in muscle strength, walking velocity and gross motor function in standing and walking in the training group.

For individuals with cerebral palsy, the clearest relationship between muscle strength and physical activity is the positive relationship between muscle strength and mobility and related functions, including gait. Weakness may also play a role in the observed decline in mobility in adults with cerebral palsy who do not exercise regularly (Maltais *et al*., 2014).

The present result disagrees with Damiano (2014), that studied the effect of progressive resistance exercise on the mobility of young people with spastic cerebral palsy and the results showed the strength was increased after 12 weeks of training but does not improve the objective measures of functional mobility in young people with cerebral palsy, there was no difference between the groups for the six-minute walk, stairs test, GMFM standing and walking dimensions.

A recent systematic review included seven studies that addressed efficacy or effectiveness of lower extremity strengthening interventions and concluded that there was sufficient evidence for short-term gains in the ability to produce force or torque but not for carryover to functional activities. The authors deemed it a yellow-light intervention that should probably be performed for children with cerebral palsy. It is important to examine the elements of strength training protocols for children with cerebral palsy. They are varied in the type of exercise, duration and frequency (Novak *et al*., 2013).

Thus, it would seem that there are many considerations when designing and implementing a strength training program for individuals with cerebral palsy including intensity, duration, which muscles to strengthen and how to strengthen them. Choice of muscles to be strengthened should depend on the functional motor goals of the individual child (Damiano *et al*., 2010).

CONCLUSION

On basis of the present study supported by the relevant literature, this study concluded that the children with spastic cerebral palsy either hemiplegic or diplegic with level I and II GMFCS had poor core stability represented by weakness of frontal and dorsal trunk muscles. So the ambulant spastic cerebral palsy still need core stability training programs with more concentration on trunk muscles as well as extremities. Also there is positive correlation between the strength of trunk muscle and the functional abilities in children with spastic CP.

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