Effect of Trunk Exercises on Trunk control, Balance and Mobility Function in Children with Hemiparetic Cerebral Palsy

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ARTICLE INFO

Article History:
Received: July 06, 2015
Accepted: Aug 04, 2015
Published: Sep 14, 2015

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ABSTRACT

Objective: To evaluate the effect of trunk exercises in addition to conventional physiotherapy program on trunk control, balance and mobility function in children with hemiparetic cerebral palsy.

Methods: Thirty spastic hemiparetic cerebral palsied children of both sexes (10-14 years, 16 girls and 14 boys) were included in this study. Children were randomly assigned into two equal groups: study and control groups. Both groups received a conventional physical therapy program. The study group additionally received trunk exercises which was provided 30 min/day, 3 days/week for 3 successive months. Participated children received baseline and post-treatment assessments using Trunk Impairment Scale (TIS), Berg Balance Scale (BBS) and dynamic gait index (DGI) to evaluate trunk control, balance and mobility function.

Results: Both groups showed significant improvements in the mean values of all measured variables post-treatment with (p<0.05). The results also showed significantly better improvement in the scores of all measured parameters for the study group, as compared to the control group (p<0.05).

Conclusion: Additional trunk exercises to conventional therapy had a beneficial effect in improving trunk control, balance and mobility function in children with spastic hemiparetic cerebral palsy.

Key words: Cerebral palsy, trunk control, balance.

Introduction

Cerebral palsy (CP) describes a group of disorders of the development of movement and posture, causing activity limitation (1,2). The extent of problems varies with the degree of disability, ranging from minor dysfunctions in the least impaired to limited motor control in the most impaired (3).

Performing everyday activities requires a flexible control of posture, meaning that we continually have to control the position of either parts of the body or the whole body in an often changing environment (3). Postural control for stability and orientation requires a complex interaction of musculoskeletal and neural systems (4,5,6). The trunk plays a critical role in the organization of postural reactions (7). The primary contribution of the trunk muscles is to stabilize the
spine and trunk, and this stabilization is essential for free and selective movements of the head and the extremities (8,9,10,11,12).

Many studies have shown that the postural muscles are dyscoordinated in children with CP (3,13,14). Assaiane et al. (15) described the trunk as a key segment in the organization of postural stabilization and orientation control. Children with CP frequently showed impaired trunk control, which can affect performances of activities of daily life such as sitting, reaching and walking (16,17,18).

The trunk is the central key point of the body; proximal trunk control is a prerequisite for distal limb movement control, balance and functional activities (19). Trunk control is the ability of the trunk muscles to allow the body to remain upright, adjust weight shift, and perform selective movements of the trunk so as to maintain the center of mass within the base of support during static and dynamic postural adjustments (20,21,22). Despite its clinical importance, research into the specific characteristics of impaired trunk control in children with CP is lacking (23).

The Trunk Impairment Scale (TIS) assesses static and dynamic sitting balance and trunk coordination, which target the body structure and function dimensions according to the International Classification System of Functioning (ICF), Disability and Health. The reliability of the TIS was examined in children with CP with good intra- and inter-observer reliability results (24).

The majority of research in children with CP is focused on assessment and treatment of upper and lower extremities (25, 26). In contrast, literature on trunk control in children with CP is scarce (27). Unlike limb muscles, the abdominal muscles need a stable origin to act efficiently, that is the pelvis, the thorax or the central aponeurosis depending upon part of trunk that is moved. Counter rotation between the upper and lower trunk is the mobility over stability task which is essential for all the functional movements. The rotation of the trunk muscle activity is not unilateral, but requires static holding of contra-lateral muscles to stabilize the central aponeurosis, so allowing the antagonist shorten and draws one side the pelvic or thorax forwards. In addition, the trunk rotators cannot function efficiently when their origin and insertion are approximated, as the spine is flexed (20).

Balance being the essential part of sitting, sit-to-stand and walking activities leads to increased risk of falling toward the paretic side is found to be significantly correlated with locomotor function and mobility reduced walking ability (28). A randomized trial that added 10 hours additional trunk exercises to regular rehabilitation had a beneficial effect in improving trunk control, particularly the dynamic sitting postural control in sub-acute stroke (29). Although proximal trunk control is a prerequisite for improving balance and weight symmetry, there is a lack of studies that reported the role of physiotherapy in treating the trunk for children with CP. Therefore, the purpose of this study was to determine the role of trunk exercises in addition to conventional physiotherapy program on trunk control, balance and mobility function in children with spastic hemiparetic cerebral palsy.

**Methods**

**Subjects:**

Thirty children with spastic hemiparetic cerebral palsy were recruited from the Alkaser AlEini hospital and pediatrics outpatient clinic of the faculty of physical therapy, Cairo University. Sixty five children with spastic hemiparetic cerebral palsy were initially screened and assessed to determine age, diagnosis, inclusion and exclusion criteria. The inclusion criteria were as follows: the participated children had a diagnosis of spastic hemiparetic cerebral palsy confirmed by their pediatric neurologists; they aged 10 to 14 years of both sexes. The levels of gross motor function were between level I and II according to Gross Motor Function Classification System (GMFCS) (30). The degree of spasticity according to Modified Ashworth Scale ranged between grade 1 and grade 2 (31). Children were cognitively competent and able to understand and follow instructions, as well as, in general they were cooperative. On the other hand, participants were excluded if they had any orthopedic surgery or spasticity- altering procedures in the previous 12 months; Children with visual, auditory, vestibular or perceptual deficits. The study was approved by the Ethics Review Committee of the Faculty of physical therapy, Cairo University and parents signed a consent form, authorizing the child’s participation. From the screened children only 38 children were fulfilled the aforementioned criteria, 8 children’s parents refused to participate in the study. The remaining thirty children were randomly distributed into two equal groups, 15 children each. Randomization process was run using the SPSS computer program (SPSS version 16). The control group received conventional physical therapy program. The study group received the same program in addition to trunk exercises.

**For evaluation:**

The participants received baseline and post-treatment assessments after three month training period by using the following tools:

The trunk impairment scale (TIS) was used to assess static and dynamic sitting balance and trunk coordination, scored up to 7, 10, and 6 points, respectively (7). The static sitting balance subscale was used to assess whether a child can sit independently and remain seated when the legs are either passively or actively crossed. The dynamic sitting balance subscale was used to evaluate the ability to actively shorten each side of the trunk, first initiated from the shoulder and subsequently initiated from the pelvic girdle. Trunk coordination test was used to assess the ability to independently rotate the shoulder girdle and pelvic girdle. The total TIS scores range between 0 and 23 points, where a higher score indicates better trunkal function.

**Abdel-aziem A et al., International Journal of Therapies and Rehabilitation Research 2015; 4 (5): 236-243**
The Berg Balance Scale (BBS) was used for evaluation of functional balance abilities of children with CP. It has 14 items of increasing difficulty for testing functional skills relevant to daily life activities from sitting to one leg stance. Each item is scored on a five point ordinal scale ranging from 0 to 4 points, with a maximal score level of 56. A higher score shows better postural balance. The items are executed within specified amount of time and test duration takes approximately 20-30 min depending on the child’s functionality. The authors found that BBS can be considered as valid for the evaluation of balance in children with cerebral palsy (32,33).

The Dynamic Gait Index (DGI) was used to measure mobility function and dynamic balance in walking and stair climbing. There are 8 items on the DGI and each item is scored on a 4-point scale [(3) Normal; (2) Mild impairment; (1) Moderate impairment; (0) Severe impairment] with a maximal score of 24. The 8 items include walking, walking with speed changes, walking with vertical and then horizontal head turns, walking with a quick pivot stop, walking over objects, walking around objects and walking up and down stairs (34).

For treatment:
During the study period, participants received no physiotherapy other than that scheduled in the study protocol. The children in both groups received conventional physiotherapy training program, for one hour, three sessions per week, for three successive months, based on neurodevelopmental treatment, composed of approximation of the upper and lower limbs in a regular and rhythmic manner, facilitation of righting, equilibrium and protective reactions, training of postural stability and equal weight shift especially on the affected side, stretching, strengthening exercises for upper and lower limbs, reflex inhibiting patterns and gait training. While the additional trunk exercises training routine for study group was conducted 30 min/day, three days per week for three successive months, in the form of selective movements of upper and lower part of trunk in supine and sitting.

Statistical analysis
The results were expressed as mean (standard deviation). Data was analyzed using the Statistical Package for Social Sciences (SPSS computer program version 16.00, Inc., Chicago, IL). Paired t-test was used to compare between the mean values of all measured parameters pre and post-treatment in each group. While the comparison between both groups pre and post treatment was carried out by using an unpaired t-test. A probability of P < 0.05 was considered to be statistically significant.

Results
Thirty spastic hemiparetic cerebral palsy children randomly distributed into two equal groups were participating in this study. The demographic characteristics of the included children were illustrated in Table 1. There was no significant difference between both groups in their ages, weights, and heights where (p= 0.753, 0.471, 0.784) respectively.

Regarding to the TIS, BBS, DGI scores from pre to post treatment, the results showed significant improvement in the ability to control trunk, balance and mobility function in both groups as shown in Table 2 (p<0.05). Comparing these results between both groups pre-treatment indicated no significant differences. While their comparison post treatment as elucidated in Tables 2 demonstrated significant differences in favor of the study group B (p<0.05).

Table (1): Demographic characteristics of participants

<table>
<thead>
<tr>
<th>Variables</th>
<th>Control group , n= 15</th>
<th>Study group , n= 15</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
</tr>
<tr>
<td>Age (years)</td>
<td>11.49 (1.43)</td>
<td>11.63 (1.40)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>134.48 (5.08)</td>
<td>135.02 (5.40)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>35.54 (5.70)</td>
<td>33.99 (5.80)</td>
</tr>
<tr>
<td>Sex (girls/boys)</td>
<td>6/9</td>
<td>10/5</td>
</tr>
<tr>
<td>Spasticity grades</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>1+</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>GMFCS level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>II</td>
<td>8</td>
<td>6</td>
</tr>
</tbody>
</table>

SD: standard deviation       GMFCS: Gross motor function classification system
Spasticity grades: Modified Ashworth Scale.

Abdel-aziem A et al., International Journal of Therapies and Rehabilitation Research 2015; 4 (5): 236-243
Table (2): Comparison between the mean values of the scores of TIS, BBS & DGI scale pre and post treatment within and between groups

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Control group, n= 15</th>
<th>Study group, n= 15</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td></td>
</tr>
<tr>
<td>TIS (static sitting balance)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre</td>
<td>4.49 (1.13)</td>
<td>4.80 (1.01)</td>
<td>0.40</td>
</tr>
<tr>
<td>Post</td>
<td>5.60 (0.82)</td>
<td>6.47 (0.52)</td>
<td>0.002</td>
</tr>
<tr>
<td>P value</td>
<td>0.001</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td>TIS (dynamic sitting balance)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre</td>
<td>4.53 (0.92)</td>
<td>4.93 (0.96)</td>
<td>0.25</td>
</tr>
<tr>
<td>Post</td>
<td>6.47 (1.19)</td>
<td>8.20 (0.86)</td>
<td>0.0001</td>
</tr>
<tr>
<td>P value</td>
<td>0.001</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td>TIS (coordination)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre</td>
<td>2.13 (0.74)</td>
<td>2.20 (0.86)</td>
<td>0.82</td>
</tr>
<tr>
<td>Post</td>
<td>3.20 (0.68)</td>
<td>3.93 (0.96)</td>
<td>0.02</td>
</tr>
<tr>
<td>P value</td>
<td>0.001</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td>TIS (total)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre</td>
<td>11.13 (1.85)</td>
<td>11.93 (2.02)</td>
<td>0.27</td>
</tr>
<tr>
<td>Post</td>
<td>15.27 (1.87)</td>
<td>18.60 (1.50)</td>
<td>0.0001</td>
</tr>
<tr>
<td>P value</td>
<td>0.001</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td>Berg balance scale (BBS)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre</td>
<td>44.47 (3.27)</td>
<td>44.93 (3.15)</td>
<td>0.69</td>
</tr>
<tr>
<td>Post</td>
<td>46.07 (3.39)</td>
<td>49.0 (3.84)</td>
<td>0.04</td>
</tr>
<tr>
<td>P value</td>
<td>0.001</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td>Dynamic gait index scale (DGI)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre</td>
<td>20.13 (0.56)</td>
<td>20.51 (0.65)</td>
<td>0.1</td>
</tr>
<tr>
<td>Post</td>
<td>20.92 (0.46)</td>
<td>22.70 (0.49)</td>
<td>0.0001</td>
</tr>
<tr>
<td>P value</td>
<td>0.001</td>
<td>0.001</td>
<td></td>
</tr>
</tbody>
</table>

SD: standard deviation    Pre: pretreatment    Post: post treatment

Motor learning literature suggests that training needs to be specific to the task that the person needs to do (19). So, the results of the present study are consistent with the study of Verheyden et al. (35) who demonstrated a therapeutic effect on the dynamic subscale as well as the more complex items of the coordination subscale of the TIS. The findings of this study reflected the improvement in postural balance control and mobility in all participating children immediately post-treatment. The significant improvement in study group may be due to the provision of sufficient opportunities to practice, by the 18 hours of trunk exercises provided in our study.

Discussion

This study was conducted to evaluate the effect of trunk exercises in addition to conventional physiotherapy program on trunk control, balance and mobility function in children with hemiparetic cerebral palsy. The results concluded that trunk exercises can be added to conventional physical therapy rehabilitation program to improve trunk control, balance and mobility function in children with spastic hemiparetic cerebral palsy.

Abdel-aziem A et al., International Journal of Therapies and Rehabilitation Research 2015; 4 (5): 236-243
The significant improvement obtained in the post-treatment mean values of the all measured variables of the control group may be attributed to the effect of conventional physical therapy program (based on neurodevelopmental treatment) which was directed toward facilitating normal patterns of postural control (righting & equilibrium reactions) & developing a greater variety of normal movement patterns particularly in the trunk & lower extremities. This agree with Ottenbacher et al. (36) who conducted a Meta analysis on the use of neurodevelopmental treatment (NDT) in paediatric populations including 37 reviews, and found that children receiving NDT or combination of NDT and other intervention performed better than 62% of subjects receiving other services. Also, the post-treatment results improvement of control group come in agreement with the findings of Dodd et al. (37) who stated that exercises and rehabilitation programs increase general physical capacity and functional independence for children with cerebral palsy.

The significant improvement of all measured variables for study group comes in agreement with Davis (20) and Verheyden, et al. (12) who found that, truncal stability is an essential core component of balance and coordinated extremity use in daily functional activities and the performance of higher level motor tasks. Also, with a study by Mudie et al. (38) who found that training the patient in the awareness of trunk position could improve weight symmetry in sitting after the early phase of the stroke.

The significant improvement in trunk control may be due to the fact that the trunk exercises mainly consisted of selective trunk movements which helped in strengthening of trunk muscles and also increased awareness of trunk position and anticipatory postural adjustments which also helped in achieving good trunk control (39).

The improvement in post treatment results of the study group may be due to improve strength of both abdominal and back muscles, as a large portion of the additional therapy focused on selective muscle strengthening, such as lifting the pelvis or the shoulder girdle and rotating the upper trunk with external resistance. Also, trunk position sense (40,41,42) and feed forward anticipatory postural adjustments (43,44,45,46) considered as another key component of truncal stability which the exercises helped enable.

Improvements in balance and gait occurred because the trunk exercises consist of the use of lower limb muscles which account in change of balance and gait. Gait improved just not because of selective flexion and extension movements but also because of rotation exercises of upper and lower trunk. Gait and balance also improved because the motor control proceeds from proximal to distal, the improved level of proximal trunk control leads to improvement in distal lower limb control which helped in attaining better balance and gait (39). Karthikbabu et al., (19) reported that the exercises consisted of selective trunk movement of the upper and the lower part of trunk had shown larger effect size index for trunk control and balance than for gait in patients with hemiplegia. This difference in gait results can be explained by the difference of age sample, as their participants was adult sample and the short duration of their rehabilitation program.

Asymmetric gait in hemiplegia is characterized by longer time spent in affected single limb stance than unaffected single limb stance (47). A study on involving the analysis of trunk kinematics during walking found that pelvic movements were unstable and asymmetrical in patients with hemiplegia (48). The results of current study is consistent with the findings of Karthikbabu et al. (19) who found that selective trunk muscle exercise training may enhance symmetrical pelvic movements, thus better weight shifting towards hemiplegic limb during walking. Moreover, they explained that with trunk exercises increased time spent in affected limb support stance may be the reason for the gait symmetry improvement. Moreover, a study by Trueblood et al. (49) reported that, proprioceptive neuromuscular facilitation based resisted anterior elevation and posterior depression of pelvic movements for trunk muscles produced more gait symmetry in patients with hemiplegia.

This study had several limitations. Firstly, the tests that used to assess the ability to perform the more demanding tasks, such as the TIS, BBS, and DGI were the only outcome variables that discriminated between both groups. Secondly, the small sample size for the study challenges the generalization of the study. Thirdly, our study only analyzed the
results between pretreatment and post-treatment assessment, we did not perform a follow up assessment. Finally, the effect of the trunk exercise training on the participants' psychologic parameters such as quality of life was not examined.

Future studies with a large number of participants are needed to confirm our results. Also, future studies should evaluate long term effects of trunk exercise training program. Certain secondary outcome variables such as, muscle strength and energy expenditure should be assessed in future studies. Finally, Future work will be needed to use other outcome measures such as posturography and electromyographic analysis and biofeedback.

In conclusion, trunk exercises program in combination with conventional physiotherapy rehabilitation program is effective in improving trunk control, balance and mobility function in children with spastic hemiparetic cerebral palsy then conventional physiotherapy program alone.

Acknowledgements

We would like to thank the children and their parents for their cooperation, and the staff of the participating centers for their collaboration.

Conflict of interest

The authors declare that the research is conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest. All work of this study was conducted in the Faculty of Physical Therapy, Cairo University and not funded, in whole or in part and this work is on our specialty in faculty of physical therapy, so there is no conflict of interest in this study. The manuscript has been read and approved by authors.

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Abdel-azim A et al., International Journal of Therapies and Rehabilitation Research 2015; 4 (5): 236-243