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Original Research Article

Does chest mobilization affect trunk control and balance in children with spastic cerebral palsy

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ABSTRACT

Background: Chest mobility has been reported to be reduced in children with spastic cerebral palsy (CP). This study was conducted to determine the effectiveness of chest wall mobilisation on trunk control and balance in children with CP.
Methods: The 32 children who participated in this single-blind trial were divided into two groups at random. Group A (n=16) received conventional intervention and chest mobilisation, while group B (n=16) received only conventional intervention. For a period of six weeks, the intervention was carried out three days a week. After six weeks of therapy, participants were reassessed using the paediatric berg balance scale (PBS) for evaluating balance and the trunk control measurement scale (TCMS) for evaluating trunk control.
Results: The Wilcoxon test was used to assess differences within the group, while the Mann Whitney 'U' test was used to determine whether there were any differences between the two groups. The pre- and post-treatment scores of the variables TCMS and PBS were used to illustrate the results as a mean and standard deviation. Comparison of each group's outcome metrics before treatment revealed no significant differences. While, comparing the results of chest mobilisation with conventional physiotherapy in group A showed a notable improvement in the ability to maintain balance and trunk control ($p<0.05$)
Conclusions: In children with CP, chest mobilisation has a positive effect and can be combined with conventional physiotherapy techniques to enhance balance and develop trunk control.

Keywords: Activities of daily living, Balance, Impairments, Spasticity

INTRODUCTION

Cerebral palsy (CP) refers to a class of chronic childhood motor impairment disorders that are distinguished by particular functional characteristics rather than by the underlying etiology. Impairment of posture and motor control, which first manifests in infancy, is a hallmark of CP. There are differences in total motor function and sensory, cognitive, communication and behaviour deficits are frequently present in addition to motor impairments.[1-3] In the western world, incidence rates of 1.5 to 2.5 per 1000 live births have been noted.[4,5] In India, there are 2.95 cases of CP for every 1000 children surveyed.[6] Everyday activities necessitate flexible posture control, which means we constantly must maintain control over the positioning of either specific body parts or the entire body in a constantly changing environment.[7] By managing the centre of gravity at the base of support, postural control is the process of ensuring that the body is positioned correctly in space, maintaining alignment and sustaining stability. For children with CP, postural control dysfunction is a serious problem. A crucial component of postural control is trunk control. As the centre of our body, the trunk stabilises the base of support for movements involving the upper and lower limbs, regulates responses to changes in balance, ensures that functional movements are successfully carried out and actively participates in actions like reaching and walking. Children with CP experience functional mobility and balance issues as a result of the absence of trunk control, which also restricts their ability to engage in ADL.[8] Immobile ribs and problems with muscle tone have been observed in children with CP. The immovable ribs obstruct proper spinal motion and trunk control. The growth and curvature of the spine are hampered by uneven tone. Because of abnormal tone like hypertonicity or spasticity, in which muscles are stiff and passive motions are restricted, the muscles between the ribs tighten and shorten and this causes the costovertebral joints to stiffen, the immobility of the rib cage can result in a number of deficits in the trunk.

The ribcage, which is a crucial component of the skeletal system and where the muscles for postural control and respiration are attached, allows the respiratory and trunk muscles to cooperate to create various pressure gradient changes that are necessary for both an ideal respiratory function and a variety of gross motor activities.[9] According to Shumway-Cook et al in 201l motor abnormalities in CP are frequently associated by poor balance control. Most functional abilities require some level of balance control to be performed competently. This ability allows a child to recover from unexpected balance disturbances caused by trips and falls or by self-inflicted instability when performing movements that push them close to their limit of stability.[10,11]

Functional balance is impacted in CP patients because they lack proper postural control mechanisms. Because the trunk is crucial to the preservation of the mechanism of postural control and the organisation of balance reactions during developmental phase, trunk control is vital for a firm foundation of support required to accomplish functional tasks for arms and legs motions.[12,13] When evaluating and intervening, the trunk should not be viewed as a whole but as a part. Our goal was to ascertain whether including chest wall mobility exercises promotes trunk control, which therefore aids in regaining balance.

METHODS

Study design

This experimental study was conducted at the Wisdom Special School in Nangloi, Delhi and the SGT Medical College Hospital and Research Institute in Gurugram, Haryana from October 2022 to March 2023.

The study involved two groups and was single-blinded and randomised. The study's blinded assessor was a licenced physiotherapist who had received training in the field. Parents were previously informed and their signed informed consent was acquired.

Participant recruitment and allocation

The following criteria were required for inclusion: CP diagnosis by a paediatrician or paediatric neurologist; age between 5 and 12 years, classification of gross motor function classification system (GMFCS) Level I, II and III; and ability to understand verbal commands. The following were listed as exclusion criteria recent lower limb surgery (within one year), botulinum toxin (BTX-A) or serial casting to lower limbs within the last three months (or planned for during the intervention or control period), completion of a core exercise group within the previous six months, neurological or orthopaedic conditions unrelated to CP and behavioural difficulties limiting ability to participate in groups.

G Power software was used to determine the sample size.[14] The t-test was used as the analyses' test to determine the mean difference between two independent groups and the sample size was 32. The effect size for the same was taken into account based on assumptions. The power was 0.80, the alpha error was 0.05, the effect size was 0.90 and it was two-tailed.

Computerised random assignment was used to assign children at random to either a treatment group or a control group. Utilising numbered, sealed and opaque black envelopes created by a researcher not involved in the study, allocation was concealed. The group assignment was not disclosed to the physical therapist who gathered the data.

Outcome measures

The trunk control is measured by Trunk control measurement scale (TCMS). A stable base of support and an actively moving body segment are the two most important parts of trunk control and TCMS can measure both. With 15 elements and a total score of 58, the TCMS assesses the static (20 total points) and dynamic (38 total points) facets of trunk control. Static trunk control for movements of the upper and lower limbs was assessed using the static subscale component. The dynamic portion was further broken down into two subscales dynamic reaching (score of 10) evaluates performance during three reaching tasks that call for active trunk movements outside the base of support, while selective movement control (score of 28) evaluates targeted trunk movements in three planes within the base of support.[15,16]

The Paediatric Balance scale (PBS) was used to gauge the children's balance. The maximum score on the scale, which consists of 14 elements and is scored from 0 points (lowest function) to 4 points (highest function), is 56 points.[17,18]

Intervention

Group A (n=16) of the two groups comprised both conventional exercises and chest mobilisation, whereas group B (n=16) only included conventional exercises. Group A was given 20 min of chest wall mobility exercises along with 45 min of conventional exercises 3 days a week for a period of 6 weeks and group B was given conventional exercises for 45 min/3 days a week for a period of 6 weeks.

Group A: conventional exercises and chest wall mobility exercises.

Conventional exercises

Stretching of psoas muscle, hamstrings and gastronemius. Strengthening of muscle abdominis obliqus, latismus dorsi and glutei. Cat and camel exercises in quadripud position, bridging, getting out of a chair. Reaching out while seated on a bolster or swiss ball in various directions to pick up coins, play with beads, zip up a garment, close a button, cut paper with scissors and weight shifting while sitting on swiss ball

Turning in circles or moving sideways, backward and diagonally.

Chest wall mobility exercises

Antero-posterior upper costal chest wall mobilization. Pacing a vertical towel roll down the patient's thoracic spine and letting gravity bring the shoulder back to the bed will enhance anterior chest wall mobility. In order to progressively lengthen the anterior chest wall, the upper extremity is either actively or passively elevated. The anterior chest is opened in this position, allowing the pectoralis and intercostal muscles to extend more easily and facilitate upper chest expansion.

Lateral chest wall mobilization

This area can be mobilised through passive lateral flexion while supine, passive lateral stretching while seated, passive lateral stretching while lying on a pillow and passive rib torsion while supine.

Upper coastal chest expansion

The child is seated and the therapist places her finger tips at the upper trapezius while resting her entire hand on the upper chest just superior to fourth rib at midclavicular line. Using light pressure, the child is instructed to inhale deeply and then exhale after expanding their chest.

Middle costal chest expansion

The therapist positions her thumb tips close to the horizontal midline (4th to 6th rib anteriorly at the mid-clavicle line) and places her finger tips at the posterior axillary line while holding the child in a sitting or supine position. The person is instructed to inhale deeply and then release the pressure after expanding their chest.

Lower costal chest expansion

The therapist places the child in a seated position and places her finger tips at the anterior axillary line with the tips of both thumbs close to the horizontal midline (below the scapular line and not lower than the 10th rib posteriorly). The child is instructed to breathe deeply before being asked to release after expanding their chest.[19,20]

Group B: conventional exercises

Group B received only conventional exercises as mentioned above.

Data analysis

The software programme SPSS 24.00 for Windows was used for data analysis. All the variables' means and standard deviations were determined.

The Wilcoxon test was used to compare the group's mean data from before and after the intervention. The Mann Whitney test was used to compare the means of the data collected prior to and following the intervention in groups A and B.

RESULTS

The study was successfully completed by a total of 32 children and the same 32 children were used to analyse the data in line with consolidated standards of reporting trials (CONSORT).[21] There were sixteen children in group A and sixteen children in group B.

With a 95% confidence interval, the level of significance was maintained at 5%. Table 1 baseline characters didn't reveal any appreciable differences between groups. Baseline characters were therefore uniform.

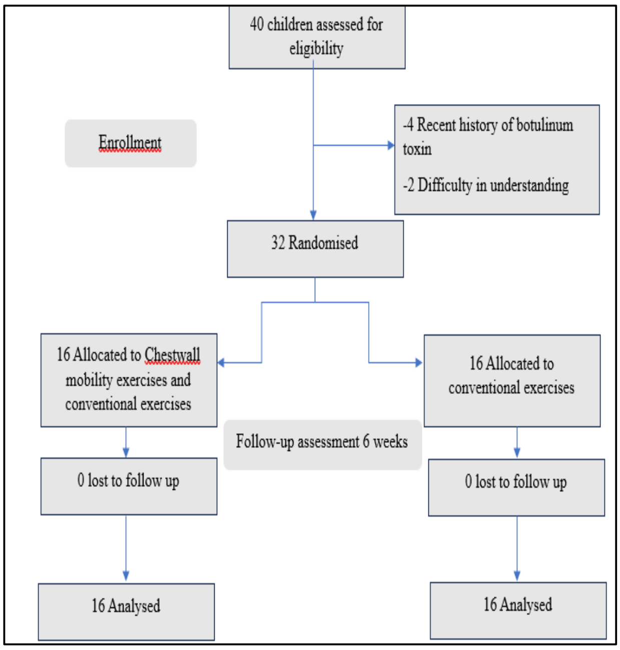

Figure 1: Flow chart of the participants.

Figure 2: Mobilisation of antero-posterior upper costal chest wall.

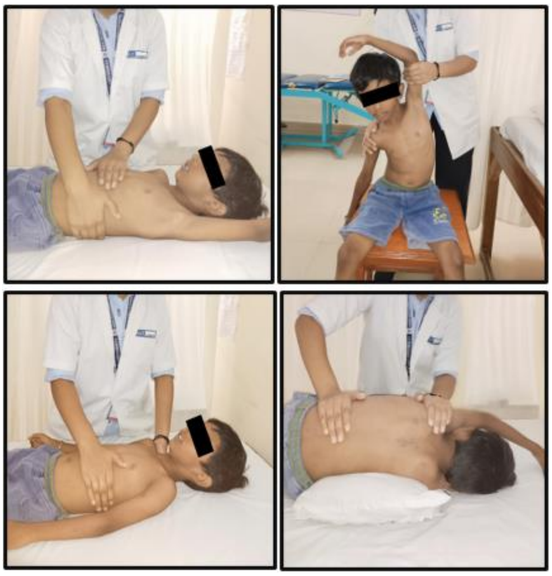

Figure 3: Mobilisation of lateral chest wall.

Figure 4: Upper coastal chest expansion.

Figure 5: Middle coastal chest expansion.

Figure 6: Lower coastal chest expansion.

Table 2 shows comparison of z value and p value of Trunk control measurement scale and Pediatric balance scale at pre intervention and post intervention within Group A. Wilcoxon rank test was performed to compare within-group differences at week 0/baseline (before intervention) and week 6 (post intervention) showing statistically significant difference with z value of-3.546 for TCMS and -3.535 for PBS (p value<0.01).

Table 3 shows comparison of z-value and p value of Trunk control measurement scale and pediatric balance scale at pre intervention and post intervention within group B. Wilcoxon Rank test was performed to compare within-group differences at week 0/baseline (before intervention) and week 6 (post intervention) showing statistically significant difference with z value of 3.555 for TCMS and 3.538 for PBS (p value<0.01). Mann- Whitney U test was used to compare the outcome measures of both groups of TCMS and PBS after the treatment and the findings showed that both groups' abilities to maintain trunk control and balance had significantly improved ($p<0.05$). There were no significant differences between the groups' pre-treatment results. However, when both groups' treatment protocols were completed, a comparison of the outcomes revealed significant improvements in favour of group A, with $p<0.05$ (Table 4).

Table 1: Baseline variables of children in the study.

Variables	Group A (n=16) Mean±SD	Group B (n=16) Mean±SD	t value	P value
Gender	M=12 (75%)	M=11 (68.75%)	-	0.705
	F=4 (25%)	F=5 (31.25%)		
Age (in years)	9.5±1.63	8.63±1.2	1.725	0.095
TCMS	31.56±1.59	30.31±1.07	2.602	0.14
PBS	31.68±1.40	32.06±1.18	0.819	0.42

M: male, F: female, TCMS: Trunk control measurement scale, PBS: Paediatric Balance scale

Table 2: Group A: results of within group comparison using Wilcoxon Test.

Variables	Pre-mean±SD	Post-mean±SD	Mean difference±SD	z value	P value
TCMS	31.56±1.59	39.87±1.82	8.31±0.23	3.546	0.01*
PBS	31.68±1.40	41.43±2.12	9.75±1.72	3.535	0.01*

TCMS: Trunk control measurement scale; PBS: Paediatric Balance scale**;** *=Significant at 0.05 level

Table 3: Group B: results of within group comparison using Wilcoxon Test.

Variables	Pre-mean±SD	Post-mean±SD	Mean difference±SD	z value	P value
TCMS	30.31±1.07	35.5±1.03	5.19±0.04	3.555	0.01*
PBS	32.06±1.18	37.18±1.16	5.12±0.02	3.538	0.01*

*=Significant at 0.05 level

Table 4: Results of between-group comparison using Man Whitney U Test.

Variables	Parameter	Group A	Group B	z value	Effect size Cohen's D	P value
		Mean±SD				
TCMS	**Pre-intervention (baseline)**	31.56±1.59	30.31±1.07	-2.317	0.92	0.2
	Post intervention (end of 4th week)	39.87±1.82	35.50±1.03	-4.836	2.95	0.001*
PBS	**Pre-intervention (baseline)**	31.68±1.40	32.06±1.18	-0.877	0.29	0.381
	Post intervention (end of 4th week)	41.43±2.12	37.18±1.16	-4.694	2.48	0.001*

*=Significant at 0.05 level

DISCUSSION

Children with CP have neuromuscular abnormalities that manifest as aberrant posture, restricted chest mobility, poor trunk control and unsteadiness, all of which have a negative impact on postural control and severely restrict everyday activities. The thorax develops normally as a result of the natural relationship between the trunk muscles, axial body parts and gravity. Although a muscle is fully activated, poor motor control results in a subnormal motor response, which makes it less able to counteract the effects of gravity. As a result, the inability of these two systems to work together properly delays the development of the rib cage. A study was conducted to assess patients with spastic CP's chest mobility using chest expansion measurements.[22] The study's findings demonstrated that, when compared to healthy controls of the same age and gender, individuals with spastic CP had less chest mobility as measured by chest expansion. Another study examined how trunk control affected ADL and respiratory muscle strength in children with CP who were classified as having levels 1 or 2 of gross motor function.[8] Children with spastic cerebral palsy typically have compromised respiratory system muscles, which support their posture and movements. They also have a higher prevalence of respiratory dysfunction, including recurrent pneumonia and atelectasis. The children with spastic CP were shown to have considerably worse ADL, respiratory muscle strength and trunk control than their peers who were typically developing. This research supports our ongoing research on the tight and spastic chest wall mobility, which highlights the necessity for workouts that increase chest mobility and, in turn, improve trunk control and balance.

The current study's findings showed a considerable difference between the two groups. Interventions consisted of conventional physiotherapy and chest wall mobility exercises. Despite the fact that cerebral palsy is not a respiratory disease in and of itself, respiratory issues in children with cerebral palsy are invariably correlated with decreased chest wall movement and insufficient respiratory muscle power, which leads to inefficient alveolar ventilation, subpar airway clearance and shortness of breath.[23] Early mobilisation of the chest wall can easily avoid these consequences. Exercises for expanding the chest and moving the chest wall together prevent the shortening of the respiratory musculature and stiffening of the costovertebral joints. This study came in contrast to a study concluded by Parmar et al, in which rib cage mobility exercises did not show significant change in 2-5 years old children with spastic cerebral palsy due to the younger age group.[9]

TCMS score in group A showed a significant mean difference of 8.31±0.23 pre and post intervention indicating the effect of chest wall mobility exercises. These results are in accordance with Diwan et al, (2014) study who concluded that chest mobility is restricted in children with CP and myofascial release techniques to the respiratory muscles is an effective way to improve chest expansion.[24] Children in group A who showed greater TCMS score by the end of treatment period, also showed greater score of PBS indicating that the children who gained good trunk control via chest wall mobility exercise also gained good balance.

Muscle contraction is necessary to maintain posture and if joint range of motion and skeletal alignment are suitable along with muscle activity, this requirement can be minimised.[25] By passively moving the joints, one can mobilise the chest wall through chest expansion exercises, joint capsule stretching and the facilitation of gliding and rolling motion of the bone surfaces. This could be quite important while planning treatment of children with CP for improvement in gross motor and daily function activities.

The sample size was small and should be increased to include more subjects and cover a longer time span. This was a six-week short-term study and no further research on the subject was done. Patients were not instructed how to use the home programme.

CONCLUSION

The present study revealed that added chest wall mobility exercises plays an important role in improving trunk control and further balance. They should therefore be a part of every child with cerebral palsy's treatment plan. Future research can be conducted on a larger sample using a variety of participants and age ranges.

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