



Case Study

The effects of neck and trunk stabilization exercises on cerebral palsy children's static and dynamic trunk balance: case series

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Abstract. [Purpose] The purpose of this case series was to examine the effects of trunk and neck stabilization exercise on the static, dynamic trunk balance abilities of children with cerebral palsy. [Subjects and Methods] The study included 11 school aged children diagnosed with paraplegia due to a premature birth. Each child engaged in exercise treatments twice per week for eight weeks; each treatment lasted for 45 minutes. After conducting a preliminary assessment, exercise treatments were designed based on each child's level of functioning. Another assessment was conducted after the eight weeks of treatment. [Results] The Trunk Control Measurement Scale evaluation showed that the exercise treatments had a significant effect on static sitting balance, selective movement control, dynamic reaching, and total Trunk Control Measurement Scale scores. [Conclusion] The results indicate that neck and trunk stabilization exercises that require children's active participation are helpful for improving static and dynamic balance ability among children diagnosed with cerebral palsy.

Key words: Neck and trunk stabilization, Trunk balance, Cerebral palsy

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INTRODUCTION

Cerebral palsy is caused by the development of non-progressive lesions in the brain. These lesions develop during prenatal or infantile development and cause muscle paralysis, muscle weakening, and coordination disorders, which hinder timely motor development. These motor impairments may be accompanied by mental retardation, visual impairments, speech impediments, perceptual disorders, and emotional disorders¹⁾. Insufficient trunk muscle postural control is the most serious concern for those who are suffering from cerebral palsy because it causes insufficient postural control and trunk stability²⁾.

The trunk is essential for limb movements, affects motor movements, and has an interdependent relationship with other body parts and nervous tissues³⁾. In normal developmental processes, trunk stability is related to the movement of the limbs. Essentially, the upper and lower limbs help to compensate for any trunk instabilities that make exist; when the trunk is stable, the upper and lower limbs are freely usable for their normal purposes⁴⁾. However, children with cerebral palsy show hypotonic symptoms; weakness of the trunk muscles; increases in upper and lower limb muscle tone; loss or delay of postural reflex; and the loss of the ability to flexibly move the upper and lower limbs, which leads to the loss of trunk stability⁵⁾. The loss of trunk control is a very important element that causes difficulties not only in sitting, playing in sitting positions, and functional hand movements such as eating¹⁾, but also in maintaining activities of daily living such as sitting in a wheelchair.

Similarly, head control is important for postural control and balance ability⁶⁾. In normal developmental processes, as the

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development of the vertebral extensor progresses from the head to the foot, the erector muscle of the upper thorax begins to become stronger and has the ability to regulate antigravity⁷). The babies are able to pull up the chin and lift the head in supine positions at approximately six months after birth. These actions require trunk stability. Thus, children with cerebral palsy cannot complete these movements sufficiently due to unstable trunk muscles. Delay in acquisition of neck orthotopic response affects the development of the muscular strength and limits the activity of the neck muscles supporting the head as well as the lack of stability of the head, resulting in a lack of head control⁶). This reduces the ability to maintain one's center of gravity and affects orientating responses and equilibrium reactions, thereby causing serious problems with balance ability⁸).

Several studies have addressed improving balance ability among children with cerebral palsy. Choi et al. reported that trunk muscle strengthening exercises positively affected upper limb functions and balance ability among children with cerebral palsy⁹). Similarly, McBurney et al. reported that when lower limb muscle strengthening exercises were applied to 11 spastic paraplegic children with cerebral palsy, lower limb muscle strength, flexibility, postures, and gait ability were improved; this study's findings also emphasized the importance of strengthening exercises for improving trunk stability¹⁰). However, previous studies primarily focused on the effects of strengthening of trunk muscles and certain muscles around the neck or on the analysis of resulting sitting balance and gross motor functions. Therefore, during normal development of a child, one of the muscles does not affect the body, but it develops through complementary movements, so stabilization of the neck and stabilization of the trunk should be done together. And the child's balance ability is necessary for the connection to the functional movement for the daily living ability¹¹). In the previous studies, there is a lack of case study of static balance and dynamic balance related with trunk and neck stabilization. Therefore, the purpose of the current study to examine the effects of trunk and neck stabilization exercises on the static and dynamic trunk balance abilities of children with cerebral palsy.

SUBJECTS AND METHODS

The study's participants were 11 school aged children who had paraplegia due to a premature birth and were diagnosed with periventricular leukomalacia (PVL) through brain MRI (Table 1). All participants were recruited from the Daegu K Child Development Center from December 2015 to February 2016. Each participant was provided with a detailed explanation of the intent of the study, indicated that they understood the intent, and agreed to participate in the experiment. The mean height of the subjects was 134.45 ± 16.40 cm and the mean weight was 33.18 ± 12.92 kg. This study was approved by Daegu University Research Ethics Committee. The participants' cognitive levels were evaluated using the Korean Wechsler Intelligence Scale for Children-IV to ensure that the subjects were able to understand and follow verbal instructions, and learn. Participation was limited to children who had not received any surgical treatment within the previous six months and who showed gross motor functional levels corresponding to Gross Motor Function Classification System (GMFCS) levels I–III. Each child participated in 45-minute exercise treatments twice per week for eight weeks. Assessments were conducted before the first treatment session at the end of the eight weeks of treatment.

Stabilization exercises of neck and trunk were adopted based on previous studies proving their effectiveness. Treatment sessions were designed according to each child's functions and levels. Each treatment session consisted of a warm-up exercise, neck and trunk stabilization exercises, postural control exercises that promote a sense of equilibrium and orientation responses, and cool down exercises. The first neck and trunk exercise involved lifting the head in a modified bridge exercise position so that lower abdominal muscles contracted when the neck was bent, thereby activating the neck flexor muscle and the lower abdominal muscles simultaneously. The second exercise involved pushing the neck backward in supine position to activate the erector muscles of the neck and the upper thoracic vertebrae through the extension of the muscles of the back of the neck. The third exercise activated the deep abdominal muscles in bridge exercise positions so that the participants would experience the posterior inclined movement of the pelvis. In each posture, they were kept for 10 seconds at a time and repeated 10 times with a rest interval of 3 seconds per each^{12, 13}).

The Trunk Control Measurement Scale (TCMS) was used to evaluate the children's trunk control ability. This scale was developed to evaluate trunk control ability for children, aged 8–15 years old, who have spastic cerebral palsy, function at the GMFCS levels I–III, and can maintain a sitting position. It is used to evaluate static balance, selective movement control, and dynamic reaching in sitting positions without wearing any walking aids and with the feet maintained off the ground. The TCMS consists of 15 items for which scores can be in a range of 0–58 points. It has strong reliability with inter-rater ICC of

Table 1. General characteristics of the participants (M ± SD)

Gender (male/female)	4/7
Age (month)	127.9 ± 32.4
Height (cm)	134.5 ± 16.4
Weight (kg)	33.2 ± 12.9
Gestational age (week)	32.2 ± 3.0
Birth weight (kg)	1.9 ± 0.8
Level of GMFCS (I, II, III/n)	4/2/5

0.98 and test-retest ICC of 0.97¹⁴).

The data were analyzed using SPSS/Windows ver. 20.0. Paired t-tests were used to compare values before and after the intervention within each group. The statistical significance level was set to $p < 0.05$.

RESULTS

After the intervention, the analysis of TCMS data showed significant effects on static sitting balance, selective movement control, dynamic reaching, and total TCMS scores ($p < 0.05$) (Table 2).

DISCUSSION

This study examined the effects of neck and trunk stabilization exercises on the static and dynamic trunk balance of children who have cerebral palsy due to a premature birth. The TCMS was used to evaluate trunk balance. Results showed that the exercises had significant effects on static sitting balance, selective movement control, dynamic reaching, and total TCMS scores. These results are similar to those of a previous study in which neck flexion exercises and bridge exercises improved sitting position trunk control for children with cerebral palsy¹⁵). Trunk stabilization exercises are a basic component of the motility of the distal part of the body, including neck movements; several studies have shown the importance of trunk stabilization exercises for these movements^{16, 17}). Furthermore, children with spastic cerebral palsy are characterized by trunk muscle weakness, which has direct effects on the functional performance of activities of daily living, and insufficient static and dynamic balance abilities. Therefore, the recovery of trunk stability and balance ability can be essential for solving these problems among children with cerebral palsy.

Information coming from the body and environments is simultaneously delivered to the neck and trunk to enable coordination between the head and limb motions, including those of the neck muscles. The functions of the head and neck set the base of the body against the surrounding environment and provide a stable base of support for the visual and vestibular systems during postural control¹⁸). In particular, the trunk provides stable attachment points to those muscles that control the head and neck regions¹⁹). However, premature babies have insufficient trunk development, cannot grasp the concept of centerlines, have acquired limited sensory information through head movements in the narrow womb, are exposed to too many sensations in the environments of neonatal intensive care units, and have instability in their movement and sensory systems⁶). Since neck muscle strength increases are connected with trunk stabilization, trunk stabilization exercises are thought to have positive effects on neck muscle strength. In addition, since the neck and the trunk are complementary to each other, neck stabilization exercises and trunk stabilization exercises should be applied together for improvement of static and dynamic balance ability. The expectation is that this combination of exercises will improve balance ability, thereby leading to improved functional activities. The postural control system consists of support, stability, and balance and requires interactions between the head, trunk, arms, and legs to keep the body upright against gravity²⁰). This supports the results of the current study and indicates that composite exercises considering the connection between the trunk and neck bring about improvement in balance ability. Thus, trunk exercises implemented together with neck stabilization exercises increase the effects on postural balance. The causes of motor disorders among children with cerebral palsy include abnormal muscle tone, muscle weakening, deficiency in balance and coordination abilities, and spasticity²¹). More specifically, children with cerebral palsy due to premature birth do not have the ability to optimize information obtained through the visual, vestibular, proprioceptive and tactile senses; they also cannot integrate information gathered from these senses with information from the central nervous system to initiate movements²²), and have remarkable muscle weakening and imbalance symptoms. Their reduced ability to maintain balance in standing and sitting positions is very important for treatment interventions designed to improve of their quality of life through daily living activities²³). In addition, the weakening of the trunk muscles and insufficient stability shown in children with cerebral palsy are obstructive factors to postural balance, which is achieved by trunk muscle control and activities of daily living²⁴). Previous studies demonstrate the effects of muscle strengthening and stabilizing exercises with minimized compensatory actions and the mobilization of accurate muscles as solutions for postural imbalance due to muscle weakness²⁵). This is also consistent with the results of the current study. The results of the present study showed, neck and trunk stabilization exercises was the basis of static and dynamic balance abilities, and that the increased neck and trunk stability might have had a positive effect thereon. Further studies may need to be conducted with more subjects on the basis of the

Table 2. Comparison of pre-post test on TCMS (M ± SD)

	Pre-test	Post-test
Static sitting balance	12.6 ± 4.4	15.0 ± 3.5*
Selective movement control	8.63 ± 6.40	12.7 ± 7.3*
Dynamic reaching	5.72 ± 3.19	8.09 ± 2.30*
Total TCMS score	27.0 ± 12.5	35.8 ± 12.2*

* $p < 0.05$, TCMS: Trunk Control Measurement Scale

findings of the present study.

However, this study has limitations that should be interpreted carefully because there is no control group and the type of cerebral palsy is limited to spastic diplegia. Based on the results of the current study, additional research with larger participant groups is needed.

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