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Case Study

The effects of neck and trunk stabilization exercises on upper limb and visuoperceptual function in children with cerebral palsy

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Abstract. [Purpose] The present study aimed to investigate the effects of neck and trunk stabilization exercises on upper limb and visuoperceptual function in children with cerebral palsy. The Jebson-Taylor hand function test and the Korean Developmental Test of Visual Perception-2 (K-DTVP-2) test were utilised. [Subjects and Methods] The study subjects were 11 schoolchildren who had paraplegia caused by premature birth, and who had been diagnosed with periventricular leukomalacia. Kinesitherapy was implemented in individual children for eight weeks, twice a week, for 45 minutes at a time. After a preliminary evaluation, kinesitherapy, including neck and trunk stabilization exercises common to all the children, was implemented for eight weeks according to the functioning and level of each child. A post evaluation was performed after the eight weeks of kinesitherapy. [Results] The intervention showed a significant effect in five subcategories of the Jebson-Taylor hand function test, as well as according to the K-DTVP-2 test. [Conclusion] Because neck and trunk stabilization exercises requiring positive participation by the children included fundamental elements of daily living motion, the exercises might have had a positive effect on upper limb and visuoperceptual function.

Key words: Neck stabilization exercises, Trunk stabilization exercises, Cerebral palsy

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INTRODUCTION

Cerebral palsy is a nonprogressive lesion, which occurs during the brain development process in the fetal period or infancy, but reflects mobility development disability as a result of the continuous limitation of activity[1]. Patients with cerebral palsy demonstrate mobility problems of insufficient head control and trunk stability, although mobility depends on the properties of each cerebral palsy type and individual child. Children with cerebral palsy find it difficult to maintain the right posture and balance due to insufficient stability of the head and the trunk, while muscle strength weakening and amyotrophy result in muscular imbalance[2]. In addition, children with cerebral palsy make inaccurate judgments with respect to the power, speed and direction required for posture control and balance. This results in limited movement control, and also in defects in visuoperceptual function and visual motor ability[3].

Visual perception, defined as the entire process of accepting and perceiving visual stimuli[4], refers to the ability of recognizing, identifying and interpreting visual stimuli in relation to previous experiences, all of which require the cerebral functions. Therefore, appropriate visuoperceptual discrimination is necessary for the development of reading and writing skills, serving as the most fundamental factor to learning something new[5]. It has been known that children with cerebral palsy who have disorders with visual perception capability are unable to adjust themselves to exercise, play and social

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activities, have problems with attention capacity and visual motor activity integration, and experience disorders in eye-hand coordination[6]. Many studies have been conducted on the improvement of children's visuoperceptual ability. Previous studies showed that the eye-hand coordination function and fine motor skills of infants with cerebral palsy were improved by the application of a visuoperceptual training program[7, 8], while an eye movement program helped to improve posture control and the visuoperceptual ability of children with spastic cerebral palsy[9].

Posture control and balance control are the basis of upper limb and visuoperceptual function. It is known from previous reports that children with spastic cerebral palsy show abnormal pelvic retroversion in the sitting position, bend the body forward and shrink their shoulders to complement the imperfect posture. This results in further limitation of arm function, and severely limited upper limb function for daily living or learning activity in the shrinking posture. It has also been reported that children with spastic cerebral palsy find it difficult to hold or gather objects, and immediately drop objects after holding them due to the low stability of the proximal part of their body[7, 10, 11].

Upper limb and visuoperceptual function are important functions that not only affect daily living motion, but also the normal developmental process. Trunk stability and posture control are important to these functions, as seen from previous reports on the correlation of head stability with trunk and visuoperceptual function, as well as the study on the correlation between trunk and head stability[12, 13]. However, a limited number of studies emphasize the effect of neck stability on posture control and trunk stability. Research into the correlation of neck stability with upper limb and visuoperceptual function is currently insufficient. It is presumed that the improvement of head and trunk stability would increase upper limb function, and also the stability of visuoperceptual function, as the head aligns with the body axis by remaining in the middle. Therefore, the objective of this case study was to investigate the effects of neck and trunk stabilization exercises on the upper limb and visuoperceptual function of children with cerebral palsy.

SUBJECTS AND METHODS

The present study's subjects were 11 schoolchildren visiting K Children Development Center, located in Daegu, Korea, who had paraplegia caused by premature birth, and who had been diagnosed with periventricular leukomalacia (Table 1). The subjects were provided with a sufficient explanation about the purpose of the present study, understood this and agreed to participate therein. The perception level of the subjects was 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. The subjects were chosen from the children who had not undergone surgical treatment within the past six months. All patients understood the purpose of this study and provided written informed consent prior to participation in accordance with the ethical standards of the Declaration of Helsinki.

The subjects were children at levels 1–3 according to the Gross Motor Function Classification System. Kinesitherapy was implemented with individual children for eight weeks, twice a week, for 45 minutes a time. Kinesitherapy was implemented after a preliminary evaluation. The post evaluation was performed after the kinesitherapy program had been completed. Kinesitherapy was designed according to the function and level of each child, and included the neck and trunk stabilization exercises common to all. Kinesitherapy included warming up, neck and trunk stabilization and posture control exercises to promote a sense of balance and orientation response, as well as a warm-down exercise, implemented for eight weeks, twice a week, for 45 minutes at a time. The first part of the neck and trunk stabilization exercise was to raise the head up in a modified bridge exercise posture in order to activate both the cervical flexor muscle and the hypogastric muscles by contracting the hypogastric muscles when bending the neck. The second part was to push the neck backward in order to activate the erector muscle of the cervical and upper thoracic vertebra by extending the muscles at the back of the neck. The third part was to activate the deep abdominal muscles in the bridge exercise posture to experience pelvic retroversion motion. The Jebson-Taylor hand function test, including seven subcategories, was used as the inventory against which to measure upper limb function. The Jebson-Taylor hand function test provides objective measurement data on standardized performance which may be compared with patients' performance, extensively evaluates hand functions generally used in daily living, enables the continuity of ability within individual hand function evaluation ranges to be recorded, and is easily applied in a short period. The Korean Developmental Test of Visual Perception-2 (K-DTVP-2) was used as an inventory to evaluate visuoperceptual function. The K-DTVP-2, developed to evaluate visuoperceptual function in children, is also able to evaluate visual motor function, including eight evaluation subcategories. The subcategories that relate to visuoperceptual function and motion intervention were employed to measure visual motor speed. The statistical data were processed using SPSS®/Windows® version 20.0. A paired t-test was performed to compare function before and after the exercises in each individual group. The significance level was $p<0.05$.

RESULTS

After the neck and trunk stabilization exercise intervention, children with cerebral palsy showed a significant difference in writing, stimulated page turning, and lifting small, large and lightweight objects, as well as large, heavy object subcategories of the Jebson-Taylor hand function ($p<0.05$) (Table 2). The subjects also demonstrated a significant difference using the K-DTVP-2 test ($p<0.05$) (Table 3).

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

Table 3. Comparison of pre-post test on K-DTVP-2 Test (M ± SD)

	Pre-test (M ± SD)	Post-test (M ± SD)
Visual-motor speed	13.5 ± 6.1	18.9 ± 8.5*

*p<0.05, K-DTVP: Korean Developmental test of visual perception

Table 2 . Comparison of pre-post test on Jabson-Taylor Hand Function Test (M ± SD)

	Pre-test (M ± SD)	Post-test (M ± SD)
Writing	5.5 ± 5.3	7.7 ± 5.6*
Stimulated page turning	3.0 ± 3.7	4.6 ± 4.7*
Lifting small object	4.9 ± 4.9	6.9 ± 4.9*
Stimulated feeding	2.3 ± 4.6	3.8 ± 5.5
Stacking	8.0 ± 4.5	9.7 ± 3.5
Lifting large, Lightweight object	2.8 ± 4.2	4.8 ± 4.4*
Lifting large, Heavy object	2.5 ± 3.2	4.5 ± 4.2*

*p<0.05

DISCUSSION

The present study was performed to investigate the effects of neck and trunk stabilization exercises on upper limb and visuoperceptual function in children with cerebral palsy using the Jebson-Taylor hand function test and the K-DTVP-2 test. After the intervention, of the seven subcategories in the Jebson-Taylor hand function test, a significant effect was found in five, namely in: short sentence writing, card turning, placing small objects into something, large & lightweight can lifting, large & heavyweight can lifting.

A significant effect was found also in visuoperceptual function. The neck secures stability by muscular endurance, which is weaker than strong muscular contraction, and plays a series of roles in supporting the weight of the head when keeping the balance between the head and the thoracic vertebra while moving the head[14]. Therefore, it is presumed that the neck and trunk stabilization exercises had a positive effect on the complementary coupling of the neck and the trunk, resulting in an improvement in the upper limb function of children with cerebral palsy. This finding supports that in a previous report that posture maintenance ability and trunk stability is needed in children with cerebral palsy in order to perform hand motions in playing and eating, and that the ability requires trunk stabilization and trunk muscle strengthening exercises[15].

Jung conducted a study on children with spastic cerebral palsy and reported that the celerity of their hands was improved by trunk stabilization exercises, which is consistent with the findings in the present study[16]. According to the results of this study, the neck and trunk stabilization exercises may have had a positive effect on the visuoperceptual function of children with cerebral palsy. Visuoperceptual function, which has a considerable effect on static posture and balance maintenance, is the perceptual ability to not only accept sensory stimuli coming from the external environment or one's own body, but also to connect the stimuli with previous experiences in order to interpret and identify the stimuli.

Therefore, the results of the present study were consistent with the previous report that visuoperceptual function is supported by the stability of the trunk and the ability to maintain balance[17]. In infants with cerebral palsy showing retardation of visuoperceptual development and physical limitation, the intervention improved visuoperceptual function through the neck and trunk stabilization exercises. Thus, it helped to develop motion coordination ability, which may be a critical part of treatment for infants with cerebral palsy. Hwang reported that an improvement in visuoperceptual function was effective in improving the fine motor skills and eye-hand coordination of infants with cerebral palsy, which also supports the findings of the present study[8].

Posture control and visuoperceptual function are important in deciding the activity performance factors of daily living, and serve as determining factors to the recovery of daily living activity and the prognosis of central nervous system patients[18]. Motor abnormality in children with cerebral palsy has complicated causes, including abnormal muscle tone, weakened muscular strength, lack of selective motor control, and damage to balance and coordination ability. Children with cerebral palsy have a significantly lower level of ability to optimize the information received by the visual, vestibular and proprioceptive senses, to integrate the information in the central nervous system, and to apply it to maintaining balance and to performing

daily living activities[19]. Therefore, previous studies showed that visuoperceptual function closely correlates with balancing ability and suggested visuoperceptual training programs, whose aim is to improve visuoperceptual function, balancing ability and daily living activity performance[20–22].

The present study was performed to investigate the effects of neck and trunk stabilization exercises on upper limb and visuoperceptual function in children with cerebral palsy. The results of the present study showed that stabilization of the neck and the trunk was the basis of upper limb and visuoperceptual function, 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 findings of the present study.

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