Differences in proprioceptive senses between children with diplegic and children with hemiplegic cerebral palsy

Hyo Jeong Ryu, PhD, PT1), Gui-bin Song, PhD, PT2)*

1) Department of Physical Therapy, College of Rehabilitation Science, Daegu University, Republic of Korea
2) Department of Physical Therapy, Yeungnam University College: 170 Hyunchung-ro, Namgu, Daegu 705-703, Republic of Korea

Abstract. [Purpose] In the present study, in order to examine the differences in proprioceptive senses between children with diplegic CP and children with hemiplegic CP, neck reposition errors were measured. [Subjects and Methods] Head reposition senses were measured after neck flexion, extension, and left-right rotation, using head repositioning accuracy tests. These tests were done with 12 children with diplegic CP and nine children with hemiplegic CP. [Results] The results indicated that children with diplegic CP had poorer head repositioning senses after movements in all directions compared to children with hemiplegic CP. [Conclusion] The results indicated that children with diplegic CP had poorer head repositioning senses after movements in all directions as compared to children with hemiplegic CP.

Key words: Cerebral palsy, Head reposition senses, Proprioceptive senses

INTRODUCTION

Neck muscles show a denser distribution of muscle spindles as compared to other muscles, and this can be interpreted to mean that high levels of proprioceptive function are required of these muscles1).

In children with cerebral palsy (CP), the proprioceptive senses cannot provide the basis for movement because of confusion among these senses due to abnormal levels of postural tension. The increased tension causes functional disorders of the muscle spindles such that they receive inadequate feedback regarding movements2). That is, unstable trunk muscles lead to a weakening of the neck flexor muscles and delays in the acquisition of localization functions, resulting in a lack of head control and asymmetric postures that cause serious problems in their ability to balance3). On reviewing previous studies, it can be seen that, although many studies have been conducted on trunk muscles and certain muscles around the neck, therapeutic interventions, and gross motion analysis, there are very few studies on balance ability and on the proprioceptive senses that form the basis for efficiency of movement in daily living4,5). The present study was therefore designed to examine the differences in proprioceptive senses between children with diplegic CP and children with hemiplegic CP by using a head position-reposition measuring instrument.

SUBJECTS AND METHODS

This study involved 21 children who suffered from diplegic and hemiplegic cerebral palsy, but did not have hearing and visual disabilities. The inclusion criteria were as follows: (1) Children with spastic diplegic CP (n=12) and hemiplegic CP...
(n=9) diagnosed by a pediatric medical doctor from brain MRI (Table 1). (2) No language or cognitive problems. A score of 24 or higher on the Mini-Mental State Examination-Korean version. (3) Levels I, II, and III of the Gross Motor Function Classification System (GMFCS). All parents of the enrolled participants provided written informed consent prior to this experiment in accordance with the ethical standards established in the Declaration of Helsinki.

The error value of the head position sense was evaluated using a head repositioning accuracy (HRA) test\(^6,7\). HRA was measured using a laser pointer attached to a helmet. It was used to measure the difference between the start (0 position) and return positions. All subjects were instructed to close their eyes, and the target was moved so that the laser pointer’s beam projected onto the target. The subjects were told to memorize this position because this was the reference position. They performed a neck flexion for 5 seconds and then they were instructed to return to the reference position. The error value was measured as the distance between the two marked points and repeated 3 times. The same procedure was followed to assess extension, right rotation, and left rotation. The chi-square and independent t-test were performed to compare the children’s general characteristics, and the differences in the error values of the head position sense (flexion, extension, and rotation) between the diplegic CP and the hemiplegic CP group. Statistical analysis was performed using SPSS 20.0 for Windows (SPSS Inc., Chicago, IL, USA) with a significance level of \(\alpha=0.05\).

**RESULTS**

There were significant differences between the error values of the joint position sense (neck flexion, extension, and rotations) of the diplegic CP group and the hemiplegic CP group (\(p>.05\)) (Table 2).

**DISCUSSION**

Children with cerebral palsy have difficulty in maintaining proper posture or in keeping their balance due to the low stability of their trunks and heads\(^8\). The weakening of the deep neck flexor muscles and the shortening of the sub-occipital muscles that appear in the forward head posture also appear in similar forms in cerebral palsy patients with poor body alignment\(^9\). Cerebral palsy patients tilt their heads more excessively, or show abnormal head directions due to muscle weakness and abnormal tension, which adds to their muscle imbalance and reduces their ability to control fine movements\(^2\). This phenomenon can be said to be typical of children with diplegic CP who have poor trunk stability. In addition, a medical history of a ‘premature birth’, which accounts for 80% of children with diplegic CP, leads to the destruction of neurologic structures due to complications, such as periventricular leukomalacia (PVL), resulting in distortions in vision and in the proprioceptive senses that make up the self-centering sensory system\(^10\). In addition, earlier studies have indicated that insufficient development of trunk stability in the womb, due to the premature birth, creates problems in postural stability, body alignment, and balance\(^11\). It can be seen from the results that children with hemiplegia show relatively better movements and postural alignment and have better proprioceptive senses than children with diplegia. Exercises to improve the proprioceptive senses have been used in therapeutic programs and have been shown to relieve the joint instability that occurs due to the impairment of the ability to control balance\(^12\). These exercises work with the damaged muscle nervous systems and improve the ability to achieve postural balance. Therefore, evaluating and treating children with cerebral palsy accurately involves considering the differences between children in relation to their proprioceptive senses. Based on the results of the present study, it is possible

| Table 1. General characteristics of the subjects |
|-----------------------------------------------|
| Gender (M/F) | Diplegic group | Hemiplegic Group |
|----------------|------------------|------------------|
| Age (years)    | 7.9±2.2          | 7.0±2.2          |
| Height (cm)    | 128.0±11.7       | 125.6±10.8       |
| Weight (kg)    | 23.2±7.4         | 22.6±6.6         |

| Table 2. Comparison of the head position sense errors with values presented as mean ± standard deviation |
|-----------------------------------------------|
| Flexion (cm) | Diplegic group | Hemiplegic Group |
|----------------|------------------|------------------|
| Extension (cm) | 19.6±5.1         | 14.6±2.2         |
| Right rotation (cm) | 19.7±5.6       | 15.3±2.9         |
| Left rotation (cm) | 20.1±5.5        | 15.5±3.0         |

*Significant difference from pre-test at <0.05
to positively affect the sensorimotor system in order to bring about improvements in joint stability and movement patterns.

REFERENCES

1) Hunt CC: Mammalian muscle spindle: peripheral mechanisms. Physiol Rev, 1990, 70: 643–663. [Medline]  
2) Wingert JR, Burton H, Sinclair RJ, et al.: Joint-position sense and kinesthesia in cerebral palsy. Arch Phys Med Rehabil, 2009, 90: 447–453. [Medline]  
3) Ikai T, Kamikubo T, Takehara I, et al.: Dynamic postural control in patients with hemiparesis. Am J Phys Med Rehabil, 2003, 82: 463–469, quiz 470–472, 484. [Medline]  
4) Lampe R, Grassl S, Mitternacht J, et al.: MRT-measurements of muscle volumes of the lower extremities of youths with spastic hemiplegia caused by cerebral palsy. Brain Dev, 2006, 28: 500–506. [Medline]  
5) Wiley ME, Damiano DL: Lower-extremity strength profiles in spastic cerebral palsy. Dev Med Child Neurol, 1998, 40: 100–107. [Medline]  
6) Heikkilä HV, Wenngren Bl: Cervicocephalic kinesthetic sensibility, active range of cervical motion, and oculomotor function in patients with whiplash injury. Arch Phys Med Rehabil, 1998, 79: 1089–1094. [Medline]  
7) Lee MY, Lee HY, Yong MS: Characteristics of cervical position sense in subjects with forward head posture. J Phys Ther Sci, 2014, 26: 1741–1743. [Medline]  
8) Bobth K: A neurophysiological basis for the treatment of cerebral palsy. Butterworth Heinemann London, 1980.  
9) Gong W: Effects of cervical joint manipulation on joint position sense of normal adults. J Phys Ther Sci, 2013, 25: 721–723. [Medline]  
10) Smorenburg AR, Ledeht A, Deconinck FJ, et al.: Visual feedback of the non-moving limb improves active joint-position sense of the impaired limb in Spastic Hemiparetic Cerebral Palsy. Res Dev Disabil, 2011, 32: 1107–1116. [Medline]  
11) Cioni G, Ferrari F, Einspieler C, et al.: Comparison between observation of spontaneous movements and neurologic examination in preterm infants. J Pediatr, 1997, 130: 704–711. [Medline]  
12) Treleaven J: Sensorimotor disturbances in neck disorders affecting postural stability, head and eye movement control. Man Ther, 2008, 13: 2–11. [Medline]