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Original Article

Differences of Chest and Waist Circumferences in Spastic Diplegic and Hemiplegic Cerebral Palsy

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Purpose: Circumference of the chest and waist can be one of clinical indicator to reflect respiratory function in children with cerebral palsy. In this study, we compared to differences in the chest/waist circumference and maximal phonation time between children with spastic diplegia and hemiplegia.

Methods: Seventeen children with spastic diplegic and hemiplegic cerebral palsy were recruited, who were matched to gender, age, height, weight, and body mass index for control of the known factors affected to respiratory function. The chest/waist circumference and were measured in each group, when children took a breath at rest and at maximal voluntary inspiration/expiration.

Results: No significant differences were found in the chest and waist circumference and expansion between the two groups. However, only in the waist expansion, children with diplegic CP were significantly lower extensibility of lung, compared to the other group. In comparison of the maximal phonation time, a significant lower score was shown in children with spastic diplegic CP, compared to children with hemiplegic CP.

Conclusion: Our results indicated that children with spastic diplegic CP had smaller chest wall and waist, compared to children with spastic hemiplegic CP. In addition, they showed a shorter time for sustaining phonation than spastic hemiplegic CP did. Therefore, spastic diplegic CP will be required for careful monitor regarding respiratory function in rehabilitation settings.

Key Words: Cerebral palsy, Chest circumference, Waist circumference, Maximal phonation time

Ⅰ. Introduction

Cerebral palsy (CP) is one of common disease in pediatric physical therapy, which is defined as a non-progressive neurological disorder that causes sensoriomotor dysfunction in physical development.[1-3] Children with CP suffer fromvarious symptoms in terms of cognitive, intelligent, and respiratory problems, aside from sensoriomotor disability. In particular, high incidence of respiratory dysfunctionin CP is observed in rehabilitation clinical settings, which consists of

pneumonia, atelectasis, bronchiectasis, and so forth.[4,5] observed in rehabilitation clinical settings, which consists of pneumonia, atelectasis, bronchiectasis, and so forth.[4,5] These clinical symptoms are assumed to result from poor cough/airway clearance, respiratory muscle weakness, kyphoscoliosis, and brachial hyperactivity. In addition, according to Plioplys et al' study,[6] a half percentile of postnatal survival is expired by respiratory problems. So, respiratory function plays an important role in performing functional activities and sustaining life quality.

Normal respiratory function is composed of contraction of the diaphragm, external/internal intercostal and abdominal muscles, which results in elevation and depression of the rib case as well as expansion of abdomen. In numerous cases of CP, inefficiency of these respiratory muscles caused by neuromuscular impairment leads to impede bio-mechanic

mechanism of normal respiratory, although no directly impairment of parenchymal lung structure and airway pathway existed.[7, 8] The respiratory dysfunction, such as swallow and low volumetric breathing could lead to decrease of parenchymal lung distensibility.[9] In addition, these problems would be affected to phonation mechanism required for normal development of language function. According to previous studies,[4, 10–12] the chest/waist circumference and maximal phonation time have been used as simple clinical assessment tools for respiratory function of children with CP.

CP is clinically classified into several kinds of major typical types according to region of involved limb, such as diplegic, hemiplegic, quadriplec CP. A variety of clinical features and symptoms have been observed depending on the types. Many children with CP belong to spastic diplegic and hemiplegic CP. To our knowledge, there are a few evidences regarding differences of chest and waist circumferences between spastic diplegic and hemiplegic CP, although circumference of the chest and waist are used as a valuable evaluation tool of respiratory function. Therefore, we investigated whether differences of chest/waist circumference and maximal phonation time were observed between spastic diplegic and hemiplegic CP.

II. Methods

1. Subjects

Seventeen children with spastic diplegic and hemiplegic cerebral palsy were recruited from a university hospital or rehabilitation facilities in local community in this study. Inclusive criterions were included as following: (1) children with spastic diplegic and hemiplegic cerebral palsy diagnosed by a pediatric medical doctor, (2) no language and cognitive problem capable of measuring respiratory function test, (3) medical clearance such as psychiatric and neurological disease except cerebral palsy, (4) below III level of the Gross Motor Function Classification System, (5) their parents' agreement for participation of this experiment. Nine spastic diplegic cerebral palsy group (SD-CP group; boys: 3, age: 9.9± 1.4) and eight spastic hemiplegic cerebral palsy group (SH-CP group; boys: 6, age: 10.4±1.9) were matched to gender,

age, height, weight, and body mass index for control of the known factors affected to respiratory function. All of their parents had written the informed consent before participation of this experiment.

2. Measurement of the chest/waist circumference and maximal phonation time

1) Measurement of chest and waist circumference and expansion

All children were lying in comfortable position on a bed in silent room for pediatric physical therapy, and their head and trunk was straightly positioned with the legs extended. The circumference of chest and waist was measured at the three respiratory points, when children breathed in and out within tidal volume without extra effort (circumference at resting), when they breathed in (circumference at maximal voluntary inspiration) and out (circumference at maximal voluntary expiration) with maximal voluntary effort. The measurement of circumference at resting in the chest and waist was performed, when their breath was hold by examiner, at the end point of a relaxed expiration within tidal volume. They were asked to breathe in and out as much as possible, and then hold their breath, when the circumference at maximal voluntary inspiration and expiration were assessed. Measurement of the chest and waist circumference was performed by the examiner who had over 5-year clinical experience with pediatric physical therapy, using a tape marked in 0.1cm increments. The chest circumference was horizontally measured at the level of articulated junction between the xiphoid process and sternum. The waist circumference was horizontally measured through the narrowest region of the trunk, which was between the lowest rib and the iliac crest of pelvis. In addition, expansion of chest and waist was calculated as the difference between maximal voluntary inspiration and maximal voluntary expiration. These methods were used by several previous studies.[10, 11, 13] Before assessment of the circumference, they were instructed to breathe in and out comfortably without extra effort for several times. During the three different points of respiratory execution, rest time was provided for three minutes, in order to prevent hyperventilation phenomenon.

2) Measurement of maximal phonation time

All children were in a sitting position on a chair without back support. They were asked to sustain 'ah" vowel sounds at a relatively comfortable vocal tone and loudness as long as possible after taking a deep breath, when examiner produced 'start sign'. At this time, examiner measured total time (second) of phonation using a stopwatch. The best value of three trials was used as individual MPT.

3. Statistical analysis

For comparison of demographic data (i.e., gender, age, weight, height, and body mass index) and dependent variables between the two groups, chi-square and independent t-test were performed in terms of the chest and waist circumference during three different conditions, and the maximal phonation time. In addition, Pearson correlation analysis was conducted among thechest and waist expansion and the maximal phonation time. All data were analyzed using statistical software, PAWS 18.0 (SPSS, Chicago, IL, USA). A level of p<0.05 was used as a cut-off level for statistical significance.

III. Results

Table 1 shows demographic information of children with spastic hemiplegic CP and spastic diplegic CP, in terms of gender, age, height, weight, and body mass index. In general, children with spastic hemiplegic CP was older, and had higher physical indices on height, Weight, and body mass index, compared to children with spastic diplegic CP. However, an independent t-test indicated that no significant differences between the two groups existed in all of demographic variables. Table 2 indicates the chest and waistcircumference in the two groups, when they breathed

in/out forcefully, and took a rest without extra effort. In addition, the chest/waist expansion and maximal phonation time were compared between the two groups. There were no significant difference between the two groups in chest circumference and expansion, although children with spastic diplegic CP had lower scores in all variables. In waist circumference, all variables were lower in children with spastic diplegic CP, compared to the other group. However, only significant difference was observed in the waist expansion between the two groups. In comparison of the maximal phonation time, children with spastic diplegic CP showed a significant shorter time than the other group did. In addition, the phonation time was significant correlated with only the waist expansion.

IV. Discussion

In the current study, we attempted to investigate differences of the chest and waist circumference between children with spastic diplegia and hemiplegia, while breathing in and out without extra effort, or taking maximal voluntary inspiration and expiration. As our first finding, regarding the chest and waist circumference at three measurement conditions, children with diplegic CP had smaller appearance and extensibility of the chest, compared to the other group, although no significant differences were statistically observed in the two groups. In our opinion, this result might be attributed that children with spastic hemiplegia showed relatively higher body mass index and distribution of boys, even if these variables were not significant between the two groups. In addition, according to previous studies,[9,] [14-16]children with cerebral palsy generally had decrease of respiratory function and low breathing quantity caused by only usage of abdominal respiratory muscles, instead of

Table 1. General characteristics of cerebral palsy with spastic hemiplegia and spastic diplegia

	Spastic diplegic CP	Spastic hemiplegic CP
Gender (M/F)	3 / 6	5 / 3
Age (years)	10.4 ± 1.9	9.9 ± 1.4
Height (cm)	135.9 ± 9.7	135.0 ± 9.9
Weight (cm)	33.7 ± 9.4	37.4 ± 10.1
BMI	0.2 ± 0.0	0.2 ± 0.0

Table 2. The chest and waist circumference and maximal phonation time in the two groups

	Spastic diplegic CP	Spastic hemiplegic CP	p-value
Chest circumference (cm)			
at resting	71.0 ± 8.8	75.0 ± 10.6	0.41
at maximal inspiration	72.4 ± 8.4	76.7 ± 10.5	0.37
at maximal expiration	69.1 ± 10.0	73.6 ± 11.1	0.45
chest expansion (cm)	3.6 ± 2.0	3.9 ± 1.7	0.77
Waist circumference (cm)			
at resting	63.6 ± 9.5	70.8 ± 11.4	0.17
at maximal inspiration	64.9 ± 9.6	71.5 ± 10.4	0.19
at maximal expiration	62.8 ± 9.3	59.4 ± 23.6	0.69
waist expansion (cm)	2.1 ± 0.7	3.6 ± 1.3	0.01
Maximal phonation time (s)	7.2 ± 1.9	10.4 ± 3.6	0.05

chest muscles, which of incoordination and weakness led to micro atelectasis and reduced lung volume. Therefore, we think that no difference is found depending on type of cerebral palsy, although the chest mobility of children with cerebral palsy was poor, compared to normal developed children.

As the second finding in comparison of the chest and waist expansion, we found that only waist expansion showed a significant difference, indicating that children with diplegic CP had lower volumetric extensibility of lower abdomen region between forceful maximal inspiration and expiration, compared to children with hemiplegic CP. In addition, children with diplegic CP significantly showed shorter time of maximal phonation than them with hemiplegic CP did. According to normal development of human respiratorymechanism,[17, 18] respiratory pattern of infant take part in the greater part of diaphragmatic breathing, due to no involvement of intercostalis, abdominalis, and head control muscles. As growing up, chest mobility have diverse movements with development of movement control of head and upper extremities. In general, thoracic abdominal breathing is began, since infant can perform segmental rolling activity successfully. Independent performance of this activity requires normal development of muscle groups related to control of the head and upper extremity, in terms of rectus abdominis, external/internal obliques, and transverses abdominis. The development of these muscle

groups involved to inspiration and expiration leads to the same normal respiratory pattern as adult's one.[19] Diplegic CP children with impairment of bilateral lower extremity and truncal muscles have difficulty in performing segmental rolling and controlling head movement, such as the above mentioned muscles.[20-22] Therefore, we thought that the waist expansion was significantly deceased in children with diplegic CP, because of reduced function of these muscles during forceful inspiratory and expiratory. However, children with hemiplegic CP who have hemisectional involvement of truncal and limbs muscles are relatively less impaired, compared to children with diplegic CP.

Respiratory dysfunction is one of the most important clinical issues, because it is directly related to basic vital function and physical development for human life, which leads to abnormal changes of musculoskeletal structures and impedes functional activities in their ADL.[7, 10, 23-25] Therefore, it is important to understanding the mechanism of various respiratory breathing patterns in children with CP, according to classification of motor-impaired types. Our findings indicated that children with diplegic CP had lower expansion of the waist region than the chest and shorter phonation period, compared to children with hemiplegic CP. Therefore, therapeutic respiratory intervention focused on diaphragmatic breathing exercise will be suggested for children with diplegic CP in pulmonary rehabilitation. We acknowledge that our study has the limitation not

considering large sampling size and pulmonary function test. Further study will be necessary for clarification of respiratory mechanism considering these factors in children with CP.

References

1. Fitzgerald DA, Follett J, Van Asperen PP. Assessing and managing lung disease and sleep disordered breathing in children with cerebral palsy. Paediatr Respir Rev. 2009;10(1):18–24.

2. Lee HY, K. K, Cha YJ. A survey on stress and coping style in mothers of cerebral palsied children. J Korean Soc Phys Ther. 2012;24(2):98–106.

3. Choi HJ, Nam KW. The effect of weight–support treadmill training on the balance and activity of daily living of children with spastic diplegia. J Korean Soc Phys Ther. 2012;24(6):398–404.

4. Park ES, Park JH, Rha DW et al. Comparison of the ratio of upper to lower chest wall in children with spastic quadriplegic cerebral palsy and normally developed children. Yonsei Med J. 2006;47(2):237–42.

5. Seddon PC, Khan Y. Respiratory problems in children with neurological impairment. Arch Dis Child. 2003;88(1):75–8.

6. Plioply AV, Kasnicka I, Lewis S et al. Survival rates among children with severe neurological disabilities. South Med J. 1998;91(2):161–72.

7. Bjure J, Berg K. Dynamic and static lung volumes of school children with cerebral palsy. Acta Paediatr Scand Suppl. 1970;59(s204):35–9.

8. O' Donnell DM. Pulmonary complications in neuromuscular disease. Adolesc Med. 2000;11(3):633–45.

9. Leopando MT, Moussavi Z, Holbrow J et al. Effect of a soft boston orthosis on pulmonary mechanics in severe cerebral palsy. Pediatr Pulmonol. 1999;28(1):53–8.

10. Ersoz M, Selcuk B, Gunduz R et al. Decreased chest mobilityin children with spastic cerebral palsy. Turk J Pediatr. 2006;48(4):344–50.

11. Chen Y, Rennie D, Cormier Y et al. Waist circumference associated with pulmonary function in children. Pediatr Pulmonol. 2009;44(3):216–21.

12. Chen Y, Rennie D, Cormier YF et al. Waist circumference is associated with pulmonary function in normal–weight, overweight, and obese subjects. Am J Clin Nutr. 2007;85(1):35–9.

13. Sievenpiper JL, Jenkins DJ, Josse RG et al. Simple skinfold–thickness measurements complement conventional anthropometric assessments in predicting glucose tolerance. Am J Clin Nutr. 2001;73(3):567–73.

14. Blumberg ML. Respiration and speech in the cerebral palsied child. AMA Am J Dis Child. 1955;89(1):48–53.

15. Shin HK. The effects of water–based exercise on respiratory function in children with spastic diplegic cerebral palsy. J Korean Soc Phys Ther. 2012;24(3):198–201.

16. Shin HK, Kim HS, Lee OB. The effect of seat surface inclination on respiratory function and speech production in sitting. J Korean Soc Phys Ther. 2012;24(1):29–34.

17. Alexander R, Boehme R, Cupps B. Normal development of functional motor skills: The first year of life. Tucson, Therapy skill builders, 1993:82–93,113–124.

18. Hong JS. Normal development for cerebral palsy treatment. Korea, Goonja, 2009:39–41.

19. Kim MH, Lee WH, Yun MJ. The effects on respiratory strength training on respiratory function and trunk control in patient with stroke. J Korean Soc Phys Ther. 2012;24(5):340–7.

20. Heyrman L, Desloovere K, Molenaers G et al. Clinical characteristics of impaired trunk control in children with spastic cerebral palsy. Res Dev Disabil. 2013;34(1):327–34.

21. Gorter JW, Rosenbaum PL, Hanna SE et al. Limb distribution, motor impairment, and functional classification of cerebral palsy. Dev Med Child Neurol. 2004;46(7):461–7.

22. Rosenbaum P, Paneth N, Leviton A et al. A report: The definition and classification of cerebral palsy april 2006. Dev Med Child Neurol Suppl. 2007;49(s109):8–14.

23. Hutzler Y, Chacham A, Bergman U et al. Effects of a movement and swimming program on vital capacity and water orientation skills of children with cerebral palsy. Dev Med Child Neurol. 1998;40(3):176–81.

24. Rose J, Haskell WL, Gamble JG. A comparison of oxygen pulse and respiratory exchange ratio in cerebral palsiedand nondisabled children. Arch Phys Med Rehabil. 1993;74(7):702–5.

25. Rothman JG. Effects of respiratory exercises on the vital capacity and forced expiratory volume in children with cerebral palsy. Phys Ther. 1978;58(4):421–5.