

Effects of Vojta approach on diaphragm movement in children with spastic cerebral palsy

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The purpose of this study was to examine the effects of Vojta approach on the gross motor function and diaphragm movement in children with spastic cerebral palsy (CP). Ten children with spastic CP were randomly assigned to a general physiotherapy group (trunk strengthening exercise and gait training) (n=5) and a Vojta approach group (n=5). Interventions were implemented for 30 min per time, 3 times a week for a total of 6 weeks. Ultrasonography was used to measure the areas of the diaphragm (during inspiration, expiration) before and after the interventions, the gross motor function measure (GMFM)-88 was used for evaluation of the gross motor function. In the results of this study, there was

a significant difference between before and after GMFM-sitting in the experimental group ($P<0.05$), a significant difference in changes of inspiration between the two groups ($P<0.05$). Given these results, Vojta approach may be presented as an effective treatment method for improving sitting position and diaphragm movement during inspiration in children with spastic CP.

Keywords: Cerebral palsy, Vojta approach, Diaphragm, Gross motor function

INTRODUCTION


Cerebral palsy (CP) refers to a group of persons who had non-progressive brain damage during their period of fetus or infant, when they were developing. They have limitations in activities due to permanent impairment of motor and postural development (Rosenbaum et al., 2007). Children with CP commonly have trunk instability, which affects postural control and movements (Frank et al., 2013; Son et al., 2017).

Sitting is a vertical position that is taken earliest in normal development. It is an important step that provides postural muscle tone (Park et al., 2001). Independent sitting plays a very important role in facilitating the use of active hands and enabling interactions with the environment (Harbourne et al., 2010). However, children with CP have insufficient ability to control postures compared to normal children due to the lack of stability of the trunk, and show abnormal muscle coordination patterns in the sitting position (Brogren et al., 1998; Liao et al., 2003). There-

fore, the abnormal postural control of children with CP leads to the loss of trunk balance and resultant increases in the muscle tone of the upper and lower limbs (Myhr et al., 1993). In addition, they show decreased respiratory function due to uncontrolled trunk stability and weakening of respiratory muscles (Park et al., 2006). It is a common problem of children with CP, which leads to declines in daily living functions (Knox and Evans, 2002; Wang et al., 2012).

Diaphragm is a major muscle that leads respiration and acts as a postural stabilizer to affect the stabilization of vertical positions such as sitting and standing (Noh et al., 2014). Many researchers emphasized about importance of diaphragm movement in patients with musculoskeletal or central nervous system disorder (Kolar et al., 2012; O'Sullivan, 2002; Son et al., 2017). Son et al. (2017) have reported that diaphragm movement was not observed at the initial step of breathing or postural stabilization movement in the children with CP.

In spite of the problems of the diaphragm movement in chil-

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dren with CP, studies on it in children with CP are still limited. Therefore, we were to examine the effects of Vojta approach on diaphragm movements in children with spastic CP.

MATERIALS AND METHODS

Participants

The subjects were 10 children with spastic CP recruited who received physical therapy in hospital. The inclusion criteria were as follows: (a) spastic CP, (b) gross motor function classification system (GMFCS) level I to III. The exclusion criteria were as follows: (a) acute fever or inflammatory disease, (b) neuropsychiatric problem, (c) surgical procedures or the administration of Botox in the previous 12 months. Informed consent was obtained from the subjects' parents for the publication.

Intervention

We divided into two groups. All groups were applied with intervention for 30 min per time, 3 times a week, for 6 weeks. The control group was applied with trunk strengthening exercise and gait training. The experimental group was applied with reflex turning 1, 2 and reflex creeping for 10 min each in 30 min in total. Reflex turning 1 is a stimulus to induce chest expansion and abdominal contraction by stimulating the breast zone in a supine position and reflex turning 2 is a stimulus to activate global reactions such as shoulder support and abdominal contraction by stimulating the 1/3 point of the inferior scapula and the anterior superior iliac spine in a side lying position. The reflex creeping is a stimulus to induce forward movements and global reactions through support for the medial epicondyle of humerus and the calcaneus in the prone position (Fig. 1).

Gross motor function measure-88

The gross motor function measure (GMFM)-88 assesses gross motor function in children with developmental disorders, espe-

cially children with CP. It is divided into five dimensions; A (lying and rolling), B (sitting), C (crawling and knee standing), D (standing), and E (walking, running, and jumping), and consists of a total of 88 items. The score for each item is in a range of 0 to 3, and the value of each dimension is recorded as a percentage (Russell, 2000). The total score of GMFM is obtained by adding up the percentage values of all areas and dividing the sum by 5. The total score of GMFM was recorded as a percentage and was measured before and after intervention.

Diaphragm area

To examine the diaphragm areas, a diagnostic ultrasound imaging system (HS-50, Samsung Medison Inc., Seoul, Korea) was used. To measure the diaphragm areas, a 7.5-MHz convex probe was placed on the abdominal wall above the anterior lower ribs on the centerline of the clavicle on the dominant hand side in a supine position, and was placed thereafter on the point where the diaphragm dome was the most clearly visible when the area was scanned transversely toward the cranium in B mode (Ha and Sung, 2016). The diaphragm areas were measured during inspiration and expiration (Fig. 2). The area was measured by drawing a horizontal line at the base of the moved diaphragm and a vertical line at the end point of the diaphragm using the NIH image J 1.5 for windows program and the measured values were recorded in pixels. The movements of the diaphragm were measured during inspiration and expiration 2 times each before and after intervention, and the mean values were used.

Statistical analysis

Statistical analysis was performed using IBM SPSS Statistics ver. 21.0 (IBM Co., Armonk, NY, USA). The results are presented as mean \pm standard deviation. Shapiro-Wilk tests were used for homogeneity and normality tests. Paired *t*-tests were used to compare the effects appearing before and after intervention within the groups, and independent *t*-tests were used to compare the effects



Fig. 1. Process of Vojta approach. The Vojta approach consisted of reflex turning 1 (A), reflex turning 2 (B), and reflex creeping (C). The intervention was continued for 30 min in total per time, 3 times a week, for 6 weeks. All step was provided by trained pediatric physiotherapist. Informed consent was obtained from the subjects' parents for the publication.

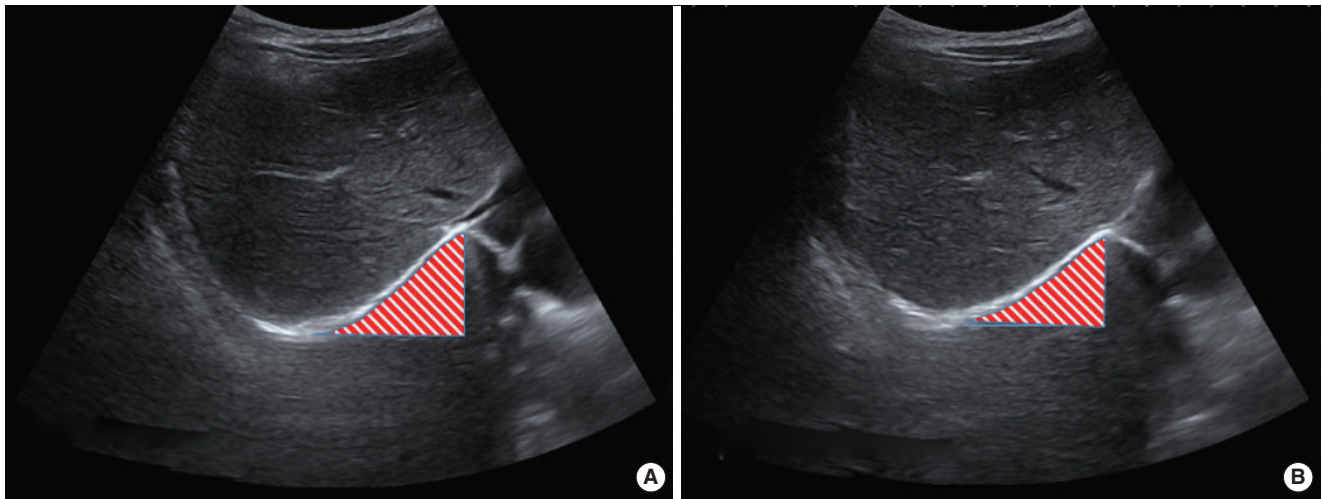


Fig. 2. Diaphragm area in inspiration (A) and expiration (B). We measured diaphragm area using ultrasound imaging system during inspiration and expiration each before and after intervention.

Table 1. General characteristics in the participants (n = 10)

Variable	Experimental (n=5)	Control (n=5)
Age (yr)	4.80 ± 1.47	4.80 ± 1.17
Height (cm)	93.00 ± 10.79	94.00 ± 5.93
Weight (kg)	13.64 ± 3.18	13.60 ± 2.22
Sex, male:female	2:3	4:1
Diplegia:hemiplegia	4:1	4:1
GMFCS, I:II:III	2:0:3	1:2:2

Values are presented as mean ± standard deviation or number. GMFCS, gross motor function classification system.

between the groups. The significance level of statistical analyses was set to $P < 0.05$.

RESULTS

General characteristics

The general characteristics of the subjects are as shown in Table 1. Both groups showed no significant difference in ages, heights, or body weights ($P > 0.05$).

Comparison of GMFM/GMFM – sitting in pre and post intervention

The score of total GMFM after intervention were no significant difference in both group ($P > 0.05$). However, the score of GMFM-sitting were significant difference within the experimental group ($P < 0.05$), but not within the control group ($P > 0.05$) (Table 2).

Table 2. Comparison of GMFM/GMFM-sitting in pre- and postintervention (%)

Variable	Preintervention	Postintervention	P-value
GMFM			
Experimental	71.63 ± 21.40	72.48 ± 20.88	0.10
Control	70.90 ± 17.43	70.75 ± 18.06	0.10
GMFM-sitting			
Experimental	92.32 ± 6.93	96.33 ± 4.77	0.02*
Control	94.33 ± 5.35	94.99 ± 5.13	0.17

Values are presented as mean ± standard deviation. GMFM, gross motor function measure. * $P < 0.05$.

Table 3. Comparison of changes in diaphragm area (post–pre) (pixel)

Variable	Experimental	Control	P-value
Inspiration	500.38 ± 884.50	-891.38 ± 1,217.76	0.04*
Expiration	491.38 ± 1,606.77	-1,500.62 ± 1,615.21	0.05

Values are presented as mean ± standard deviation. * $P < 0.05$.

Comparison of changes in diaphragm area

The changes of diaphragm area in inspiration was significant difference in the experimental group ($P < 0.05$), but not in the control group ($P > 0.05$). The changes of diaphragm area in expiration were not significant difference in both group ($P > 0.05$) (Table 3).

DISCUSSION

Children with CP do not experience normal motor development and show neurodevelopmental impairment so that their respiratory functions are remarkably poorer compared to normal

children (Ersöz et al., 2006; Son et al., 2017). The reduction in respiratory function may be due to insufficient respiration ability and weakness of respiratory muscles (Kwon and Lee, 2013). On the other hand, children with CP who could walk have better respiratory function than those who could not walk (Lee and Kim, 2014). Ersöz et al. (2006) reported that although the respiratory problems of children with CP are not caused by CP itself but are associated with the deformation of the chest wall structure due to low respiratory muscle strength and decreased movements of the chest wall.

In the present study, we confirmed that the total score of the GMFM-88 for gross motor function showed no significant differences in both groups. However, the GMFM-sitting showed significant difference in the experimental group. In addition, there were significant differences in changes of inspiration between the two groups. The diaphragm affects the trunk control together with abdominal muscles, the abdominal muscle located in front of the abdominal cavity is extended or shortened following inspiration or expiration (Hodges et al., 2001; Kim and Park, 2018). Therefore, the contraction of the diaphragm increases the pressure in the abdominal cavity leading to increases in the spine stability (Hodges and Gandevia, 2000). In the previous studies, postural control and respiratory capacity were correlated with each other (Saunders et al., 2004; Zafar et al., 2018). Shin et al. (2015) reported that sitting posture affects respiratory function. Seat surface inclined anterior 15° had a greater effect on respiratory function than a seat surface inclined posterior 15°. In a study of Son et al. (2017), dynamic neuromuscular stabilization application to children with CP improved the trunk stability and gross motor function by improving diaphragm movement. Ha and Sung (2016) reported the increment of diaphragm area after Vojta approach applied to normal adults. Furthermore, Kolar et al. (2012) reported a decrease in diaphragm movement by using magnetic resonance imaging in patients with low back pain. In our results taken together, indirect stimulation suggest that the diaphragm is involved in respiration and posture maintenance because of increased diaphragm movement of the GMFCS II and III who are poor stability in sitting positions.

We supposed that indirect stimulation of the diaphragm through stimulation point in the Vojta approach would have affected the diaphragm movement during inspiration. This may increase diaphragm movement and abdominal pressure, which affected the improvement of trunk stability in the sitting position. Giannantonio et al. (2010) also suggested that Vojta approach is effective treatment method improving respiratory capacity and

motor development of children with CP by activating postural control and respiratory muscles. Therefore, Vojta approach can be presented as an effective treatment for improvement of the diaphragm movement in children with CP.

This study has limitations such as difficulties in generalizing its contents because our sample size was relatively small; also, insufficient findings to explain respiratory functions because the study was limited to the diaphragm area. Future studies should be conducted for the improvement of the overall respiratory and motor functions.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

REFERENCES

- Brogren E, Hadders-Algra M, Forssberg H. Postural control in sitting children with cerebral palsy. *Neurosci Biobehav Rev* 1998;22:591-596.
- Ersöz M, Selçuk B, Gündüz R, Kurtaran A, Akyüz M. Decreased chest mobility in children with spastic cerebral palsy. *Turk J Pediatr* 2006;48:344-350.
- Frank C, Kobesova A, Kolar P. Dynamic neuromuscular stabilization & sports rehabilitation. *Int J Sports Phys Ther* 2013;8:62-73.
- Giannantonio C, Papacci P, Ciarniello R, Tesfagabir MG, Purcaro V, Cota F, Semeraro CM, Romagnoli C. Chest physiotherapy in preterm infants with lung diseases. *Ital J Pediatr* 2010;36:65.
- Ha SY, Sung YH. Effects of Vojta method on trunk stability in healthy individuals. *J Exerc Rehabil* 2016;12:542-547.
- Harbourne RT, Willett S, Kyvelidou A, Deffeyes J, Stergiou N. A comparison of interventions for children with cerebral palsy to improve sitting postural control: a clinical trial. *Phys Ther* 2010;90:1881-1898.
- Hodges PW, Cresswell AG, Daggfeldt K, Thorstensson A. In vivo measurement of the effect of intra-abdominal pressure on the human spine. *J Biomech* 2001;34:347-353.
- Hodges PW, Gandevia SC. Changes in intra-abdominal pressure during postural and respiratory activation of the human diaphragm. *J Appl Physiol* (1985) 2000;89:967-976.
- Kim SH, Park SY. Effect of hip position and breathing pattern on abdominal muscle activation during curl-up variations. *J Exerc Rehabil* 2018;14:445-450.
- Knox V, Evans AL. Evaluation of the functional effects of a course of Bobath therapy in children with cerebral palsy: a preliminary study. *Dev Med Child Neurol* 2002;44:447-460.

- Kolar P, Sulc J, Kyncl M, Sanda J, Cakrt O, Andel R, Kumagai K, Kobesova A. Postural function of the diaphragm in persons with and without chronic low back pain. *J Orthop Sports Phys Ther* 2012;42:352-362.
- Kwon YH, Lee HY. Differences of respiratory function in children with spastic diplegic and hemiplegic cerebral palsy, compared with normally developed children. *J Pediatr Rehabil Med* 2013;6:113-117.
- Lee HY, Kim K. Can walking ability enhance the effectiveness of breathing exercise in children with spastic cerebral palsy? *J Phys Ther Sci* 2014;26:539-542.
- Liao SF, Yang TF, Hsu TC, Chan RC, Wei TS. Differences in seated postural control in children with spastic cerebral palsy and children who are typically developing. *Am J Phys Med Rehabil* 2003;82:622-626.
- Myhr U, von Wendt L, Sandberg KW. Assessment of sitting in children with cerebral palsy from videofilm. *Phys Occup Ther Pediatr* 1993;12:21-35.
- Noh DK, Lee JJ, You JH. Diaphragm breathing movement measurement using ultrasound and radiographic imaging: a concurrent validity. *Biomed Mater Eng* 2014;24:947-952.
- O'Sullivan PB, Beales DJ, Beetham JA, Cripps J, Graf F, Lin IB, Tucker B, Avery A. Altered motor control strategies in subjects with sacroiliac joint pain during the active straight-leg-raise test. *Spine (Phila Pa 1976)* 2002;27:E1-8.
- Park ES, Park CI, Lee HJ, Cho YS. The effect of electrical stimulation on the trunk control in young children with spastic diplegic cerebral palsy. *J Korean Med Sci* 2001;16:347-350.
- Park ES, Park JH, Rha DW, Park CI, Park CW. 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;47:237-242.
- Rosenbaum P, Paneth N, Leviton A, Goldstein M, Bax M, Damiano D, Dan B, Jacobsson B. A report: the definition and classification of cerebral palsy April 2006. *Dev Med Child Neurol Suppl* 2007;109:8-14.
- Russell DJ, Avery LM, Rosenbaum PL, Raina PS, Walter SD, Palisano RJ. Improved scaling of the gross motor function measure for children with cerebral palsy: evidence of reliability and validity. *Phys Ther* 2000;80:873-885.
- Saunders SW, Rath D, Hodges PW. Postural and respiratory activation of the trunk muscles changes with mode and speed of locomotion. *Gait Posture* 2004;20:280-290.
- Shin HK, Byeon EJ, Kim SH. Effects of seat surface inclination on respiration and speech production in children with spastic cerebral palsy. *J Physiol Anthropol* 2015;34:17.
- Son MS, Jung DH, You JSH, Yi CH, Jeon HS, Cha YJ. Effects of dynamic neuromuscular stabilization on diaphragm movement, postural control, balance and gait performance in cerebral palsy. *NeuroRehabilitation* 2017;41:739-746.
- Wang HY, Chen CC, Hsiao SF. Relationships between respiratory muscle strength and daily living function in children with cerebral palsy. *Res Dev Disabil* 2012;33:1176-1182.
- Zafar H, Albarrati A, Alghadir AH, Iqbal ZA. Effect of different head-neck postures on the respiratory function in healthy males. *Biomed Res Int* 2018;2018:4518269.