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Original Article

Can Walking Ability Enhance the Effectiveness of Breathing Exercise in Children with Spastic Cerebral Palsy?

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Abstract. [Purpose] The purpose of this study was to compare differences in respiratory pressure and pulmonary function and the effectiveness of respiratory feedback training according to walking ability in children with cerebral palsy (CP). [Subjects and Methods] Twenty-three children with spastic CP were enrolled in the final analysis and were divided into an independent walking group (n=12) and non-independent walking group. All children received respiratory feedback training for four weeks. Before and after the training, respiratory muscle strength was measured and a pulmonary function test was performed. [Results] Comparison of respiratory pressure and pulmonary function test results between the two revealed that the independent walking group had significantly higher respiratory function than the other group in all variables except peak expiratory flow. In comparison of changes in respiratory function between the two groups, the independent walking group showed significantly higher improvement of respiratory function in terms of maximal inspiratory pressure, maximal expiratory pressure, and forced vital capacity. [Conclusion] These findings showed that children with independent walking ability had better respiratory muscle strength and pulmonary function compared with children without independent walking ability. Understanding respiratory function and the effectiveness of respiratory training according to walking ability will be valuable clinical information for respiratory assessment and therapy in children with CP.
Key words: Cerebral palsy, Respiratory function, Walking ability

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INTRODUCTION

Respiration is an essential physiologic component for maintaining vital functions and performing physical activities in the human body[1)]. Enhanced respiration function enables a relatively high efficiency of physiologic competence by increasing the capacity for physical activity[2)]. On the other hand, pathologic conditions in the respiratory system cause shortness of breath, poor airway clearance, lung distensibility, and so forth[3–5)]. These problems deteriorate the quality of life and are life threatening[6)]. In particular, pulmonary disease in children can have a harmful influence on physical development related to sensorimotor function and can directly impair cardiopulmonary systems[7, 8)].

Cerebral palsy (CP) is one of the major neurological diseases that cause physical dysfunction such as sensorimotor and respiratory dysfunction[9, 10)]. Motor dysfunction induces paralysis or weakens respiratory muscles, and this gives rise to an abnormal distorted chest, restriction of physical activity, and delayed development of the cardiopulmonary system[11)]. For recovery of these respiratory symptoms, respiratory training programs have increasingly been view as clinically necessary. Recent studies have revealed that physiological function related to respiration was preserved via walking ability by enabling subjects to perform a variety of vigorous physical activities[12, 13)]. These results suggest that walking ability may be associated with preservation or development of respiratory functions. However, to our knowledge, little previous literature concerning comparison of the effectiveness of respiratory training according to walking ability has been published.

Therefore, in the current study, we attempted to compare differences in respiratory pressure and pulmonary function and the effectiveness of respiratory training depending on walking ability in children with CP.

SUBJECTS AND METHODS

Twenty-five children who suffered from spastic hemiplegic and diplegic cerebral palsy were recruited in this study, according to following inclusive criteria: (1) children with spastic hemiplegic or diplegic cerebral palsy diagnosed by a pediatric neurologist from their brain MR image, (2) com-

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municative disability in language or intellectual problem capable of measuring respiratory function, (3) no psychiatric or neurological symptoms except cerebral palsy, and (4) belonged to levels I, II, and III of the Gross Motor Function Classification System (GMFCS). According to independent walking ability considering the GMFCS level and clinical assessment by a physical therapist with over five years of experience, they were divided into an independent walking group and non-independent walking group. The independent walking group contained subjects classified into GMFCS levels I and II, and the non-independent walking group contained subjects classified into GMFCS level III. Twelve and 13 children with CP belonged to the independent walking group (6 boys, mean age 9.5±2.1) and non-independent walking group (7 boys, mean age 10.5±1.5), respectively. All parents of children provided written informed consent before participation in this study in accordance with the Helsinki declaration, and this study was approved by the local ethics committee.

All children took part in respiratory training using feedback for 20 minutes per day, 3 times a week for 4 weeks, and received conventional physical therapy for 30 minutes per visit, 2 to 3 times a week, which focused on gross motor tasks and functional activities including independent sitting, walking, stair climbing, and so forth. A SpiroTiger (Idiag AG, Volketswil, Switzerland) was used as the device for biofeedback respiratory training; this device is designed to improve respiratory function by providing feedback on the subject's performance. Children sat on a chair comfortably with their head and trunk straight, took the mouthpiece into their mouth, and placed a nose clip on their nose, ensuring that breathing occurred exclusively through the device. They were instructed to watch the monitor and to inhale when the red bar reached "in" on the display panel of the device and they heard a beep sound, whereas they were instructed to exhale when the red bar reached "out" on the device and they heard a beep sound. Visual and auditory feedback provided through the device play an important role in restricting the subject's breathing to the threshold value of isocapnia. When symptoms of fatigue or hyperventilation were observed in a subject during respiratory training, training was stopped, and the subject was allowed to rest.

To evaluate the effect on respiratory function after respiratory training for 4 weeks, respiratory pressure was measured and a pulmonary function test (PFT) was performed. All children were positioned in a chair sitting with their head and trunk straight up and the hip and knee joints flexed at 90°. Measurements of respiratory pressure and pulmonary function were performed by the same examiner throughout the entire experiment. The respiratory pressure was measured using a MicroRPM Pressure Meter (Micro Direct Inc., Lewiston, ME, USA), which assessed the highest pressure that respiratory muscles are able to generate against an occlusion at the mouth. Children were asked to inhale or exhale against the obstructed mouth piece, with maximal voluntary effort, while keeping the lips sealed tightly around the mouthpiece. In the best of these trials, the values of maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP) were acquired. The PFT was performed using a spirometer (Vmax 229, SensorMedics, USA). All children were instructed to breathe in and then to breathe out via a mouth piece as deeply and fast as possible. The test was conducted a total of three times with an appropriate rest period for prevention of hyperventilation. In the best of these trials, the values of forced vital capacity (FVC), forced expiratory volume at one second (FEV_1), and peak expiratory flow (PEF) were acquired.

Table 1. Demographic information of the two groups

	Independent walking group	Non-independent walking group
Age (years)	9.3±2.0	10.8±1.4
Gender (M/F)	12 (7/5)	11 (4/7)
Height (cm)	134.9±12.0	132.8±8.0
Weight (kg)	35.5±12.4	29.0±4.8
Chest circumference (cm)	74.6±10.8	69.5±4.5
Heart rate (beats/min)	82.7±9.7	79.5±7.0
Respiratory rate (breaths/min)	25.0±2.2	25.6±3.4

Values are expressed as frequencies or means ± SD

All data were analyzed using statistical software, PAWS 18.0 (SPSS, Chicago, IL, USA). The χ^2 test was conducted to examine differences in gender distribution between the two groups. The Independent t-test was performed to compare demographic data (i.e., age, weight, height, chest circumference, heart rate, and respiratory rate) and dependent variables (i.e., MIP, MEP, FVC, FEV_1, and PEF) between the two groups. The alpha level for statistical significance was set at 0.05.

RESULTS

Demographic information for the independent walking and non-independent walking groups are shown in Table 1. No statistical differences between the two groups were found in terms of age, gender, height, weight, chest circumference, heart rate, and respiratory rate ($p>0.05$).

Of the twenty-five subjects included in this study, two participants dropped out before the posttest in the non-independent walking group. One subject gave up the training due to extremely poor conditions, and another participant failed to participate 2 or 3 times. Therefore, twelve children in the independent walking group and eleven children in the non-independent walking group finished this experiment.

In comparison of respiratory function at the pretest including respiratory pressure (i.e., MIP and MEP) and the pulmonary function test (FVC, FEV_1, and PEF) between the two groups, the independent t-test showed significant differences in MIP, MEP, FVC, and FEV_1, indicating that the independent walking group had higher respiratory function than the other group in all variables except PEF. In comparison of the changes in respiratory function between the two groups, the independent walking group showed significantly higher improvement of respiratory function in term of MIP, MEP, and FVC ($p<0.05$) (Table 2).

Table 2. Changes in respiratory pressure and pulmonary function between the independent walking group and non-independent walking group

		Independent walking group (n=12)			Non-independent walking group (n=11)		
		Pretest	Posttest	Changes	Pretest	Posttest	Changes
Respiratory pressure	MIP (cmH_2O)	36.9±12.3	42.8±12.9	5.9±1.9	21.4±7.4*	30.6±7.5*	9.2±2.8*
	MEP (cmH_2O)	48.9±18.5	55.5±17.8	6.6±3.1	29.6±10.4*	40.2±11.5*	10.6±3.3*
Pulmonary function	FVC (ℓ)	1.6±0.5	1.8±0.6	0.2±0.2	0.9±0.4*	1.3±0.3*	0.4±0.2*
	FEV_1 (ℓ)	1.4±0.5	1.6±.06	0.2±0.3	0.8±0.3*	1.2±0.3	0.4±0.3
	PEF (ℓ/sec)	2.7±1.4	2.8±1.5	0.2±0.8	1.8±0.7	2.3±0.6	0.5±1.0

*Values represent the results of independent t-tests and are significant at the $p<0.05$ level in comparisons between the CP children in the independent walking group and non-independent walking group.

DISCUSSION

The first findings of the current study showed that children with CP who had independent walking ability possessed stronger showed better improvement of respiratory muscles and pulmonary function compared with children without independent walking ability. Respiratory pressure and the PFT have been used to measure the strength of respiration muscles and lung capacity, which is one of routine procedures for measurement of respiratory function, along with PFT. These findings are supported by several previous studies, indicating that children who were capable of more vigorous physical activity showed better respiratory function compared with children without independent walking ability[14–16]. The low cardiopulmonary capacity in CP is due to restrictive lung dysfunction resulting from limited movement and not because of parenchymal lung dysfunction[3, 17, 18]. Therefore, we deduced that children who were capable of more vigorous physical activity showed better respiratory function.

In the second findings, the two groups showed improvement of all variables after 4 weeks of respiratory training. However, in comparison of the changes in respiratory function between the two groups, the non-independent walking group showed significantly better improvement of MIP, MEP, and FVC compared with the independent walking group. We think that this might be attributable to the ceiling effect in the independent walking group. In other words, the independent walking group may have already reached the upper level of their capacity in respiratory function, whereas the non-independent walking group may have had more potential for its improvement.

It is a generalized fact that walking disability can accompany respiratory dysfunction in children with CP, which together result in disturbance of normal motor development and restriction of functional activity in daily life[14, 19, 20]. Elucidation of differences in respiration function and effectiveness of respiratory training according to walking ability is an important clinical issue. Therefore, we expect that our results will be valuable for physical therapists in evaluating respiratory function and applying training programs in children with CP. A limitation of this study is the small sample size due to difficulty in recruiting children with CP. Further study will be required to consider this limitation and other clinical issues, such as differences in respiratory function according to level of walking ability and metabolic equivalence.

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