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Differences of Respiratory Function According to Level of the Gross Motor Function Classification System in Children with Cerebral Palsy

Yong Hyun Kwon, PhD, PT[1)], Hye Young Lee, PhD, PT[2)*]

[1)] *Department of Physical Therapy, Yeungnam College of Science and Technology, Republic of Korea*
[2)] *Department of Physical Therapy, Keimyung University Dongsan Medical Center: 56 Dalseong-ro, Jung-gu, Daegu 700-712, Republic of Korea*

Abstract. [Purpose] The current study was designed to investigate the difference in lung capacity and muscle strengthening related to respiration depending on the level of the Gross Motor Function Classification System (GMFCS) in children with cerebral palsy (CP) through tests of respiratory function and respiratory pressure. [Subjects and Methods] A total of 49 children with CP who were classified as below level III of the GMFCS were recruited for this study. They were divided into three groups (i.e., GMFCS level I, GMFCS level II, and GMFCS level III). All children took the pulmonary function test (PFT) and underwent respiratory pressure testing for assessment of respiratory function in terms of lung capacity and respiratory muscle strength. [Results] The GMFCS level III group showed significantly lower scores for all tests of the PFT (i.e., forced vital capacity (FVC), forced expiratory volume at one second (FEV_1), and slow vital capacity (SVC)) and testing for respiratory pressures (maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP)) compared with the other two groups. The results of post hoc analysis indicated that the GMFCS level III group differed significantly from the other two groups in terms of FVC, FEV_1, MIP, and MEP. In addition, a significant difference in SVC was observed between GMFCS level II and III. [Conclusion] Children with CP who had relatively low motor function showed poor pulmonary capacity and respiratory muscle weakness. Therefore, clinical manifestations regarding lung capacity and respiratory muscle will be required in children with CP who demonstrate poor physical activity.
Key words: Cerebral palsy, Gross motor function, Respiratory muscle strength

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INTRODUCTION

Cerebral palsy (CP) is a developmental disorder of movement and posture caused by a nonprogressive lesion to the immature brain, which can induce a variety of developmental motor disabilities and clinical presentations[1, 2)]. Clinically, movement-related disorders have traditionally been classified according to type of muscle tone abnormality (i.e., spastic, athetoid, and ataxic type) and involved limb (i.e., hemiplegic, diplegic, and quadriplegic type)[3)]. Apart from the traditional classification, it is an important clinical factor for evaluation of functional level for motor ability in children with CP. Therefore, currently, the Gross Motor Functional Classification System (GMFCS) has been widely adopted in clinical settings for diagnosis of functional motor level in CP[4, 5)].

Along with motor disability, children with CP can have abnormality of respiratory function, such as poor airway clearance, respiratory muscle weakness, and lung distensibility[6, 7)]. These symptoms are caused by consequences of neuromuscular impairment resulting from brain injury. Numerous previous studies have reported a close association of respiratory function with motor ability[8–10)]. However, to the best of our knowledge, little evidence regarding differences in respiratory function depending on functional level of motor ability in CP has been published. Therefore, in the current study, we attempted to determine whether a difference in respiratory function could be found using tests of pulmonary function and respiratory pressure according to the GMFCS level in children with CP.

SUBJECTS AND METHODS

Forty-nine children with cerebral palsy were recruited for this study. Children with CP participated according to the following criteria: (1) spastic diplegic and hemiplegic cerebral palsy diagnosed by a pediatrician or pediatric neurologist from their brain MR image, (2) belong to levels I, II, and III in assessment of the GMFCS, (3) cognitive and language ability sufficient to perform respiratory function tests, and (4) no psychiatric or neurological disease except cerebral palsy. Thirty-eight of the children had spastic diplegic cerebral palsy (17 boys, age: 10.3±1.8), and 11 were children with spastic hemiplegic cerebral palsy (8 boys,

*Corresponding author. Hye Young Lee (E-mail: happypt@hanmail.net)

Table 1. Demographic information for the three groups according to levels of the Gross Motor Functional Classification System

	GMFCS level I	GMFCS level II	GMFCS level III
Age (years)	10.1±1.4	9.6±2.2	10.8±1.4
Gender (M/F) 0.138	16 (9/7)	13 (9/4)	20 (7/13)
Height (cm)	136.8±10.1	135.8±15.1	134.2±9.1
Weight (kg)	38.4±9.2	31.9±9.1	30.0±5.9
Body surface area (m^2)	1.19±0.2	1.1±0.2	1.1±0.1

Table 2. Comparison of respiratory function among the three groups

		GMFCS level I (n=16)	GMFCS level II (n=13)	GMFCS level III (n=20)
Respiratory Function	FVC (l)	1.4±0.5	1.6±0.4	1.1±0.5*†
	FEV_1 (l)	1.3±0.5	1.4±0.4	1.0±0.4*†
	PEF (l/sec)	2.8±1.3	2.6±0.8	2.1±0.8
	SVC (l)	2.2±1.1	2.7±1.2	1.8±0.6†
	TV (l)	0.6±0.3	0.6±0.4	0.4±0.2
Respiratory Pressure	MIP (cmH_2O)	34.3±14.4	35.5±11.2	23.4±10.4*†
	MEP (cmH_2O)	45.3±14.3	46.5±19.5	33.2±14.2*†

The superscripts indicate the results of post hoc analysis using the LSD procedure. An asterisk (*) indicates significance at the $p<0.05$ level in comparison between CP children in the GMFCS level I group and those in the GMFCS level III group, and an obelisk (†) indicates comparison between CP children in the GMFCS level II group and those in the GMFCS level III group.

age: 10.9±1.2). According to their GMFCS levels, they were divided into three different groups (i.e., GMFCS level I, GMFCS level II, and GMFCS level III). Ultimately, there were 16, 13, and 20 children in the GMFCS level I, II and III groups, respectively. All parents of the children gave written informed consent prior to their child's participation in this experiment. The study protocol was approved by the local ethics committee.

The pulmonary function test (PFT) and measurement of respiratory pressure were performed by the same examiner throughout the entire experiment for evaluation of respiratory function, such as lung capacity and respiratory muscle strength. All children took the tests in a sitting position on a chair with a backrest. A spirometer (Vmax 229, SensorMedics, USA) was used for the PFT. All children were asked to take a breath and then to blow out through a mouth piece while in a sitting position, as deeply and rapidly as possible. The PFT was completely conducted three times with a sufficient break between each trial for prevention of hyperventilation. For the best trial of three, forced vital capacity (FVC), forced expiratory volume at one second (FEV_1), peak expiratory flow (PEF), slow vital capacity (SVC), and tidal volume (TV) were acquired.

The maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP) were adopted for measurement of respiratory pressure for muscle strength related to respiration. These tests assess the highest pressure that respiratory muscles are able to generate against an occlusion at the mouth using a MicroRPM (Micro Direct Inc., Lewiston, ME, USA). Children were instructed to breathe in or out against the occluded mouth piece with maximal voluntary effort and as much force as possible while keeping the lips sealed tightly around the mouthpiece and remaining in a sitting position.

The χ^2 test and one-way ANOVA were performed for comparison of demographic information (i.e., age, gender, height, weight, and body surface area) and respiratory function (i.e., FVC, FEV_1, PEF, SVC, TV, MIP, and MEP) among the three groups. The LSD procedure was performed for post hoc analysis. Statistical software, PAWS 18.0 (SPSS, Chicago, IL, USA), was used in analysis of all data, and statistical significance was considered at the level of $p<0.05$.

RESULTS

Table 1 shows demographic information for the three groups. No statistical differences in any demographic variables were observed among the three groups in terms of age ($p=0.13$), gender distribution ($p=0.09$), height ($p=0.81$), and body surface area ($p=0.09$) except for weight ($p=0.01$).

Table 2 shows a comparison of respiratory function among the three groups. In all respiratory variables, children with CP in the GMFCS level III group showed lower scores than other children with CP. According the results of one-way ANOVA, statistical significance was observed for FVC, FEV_1, SVC, MIP, and MEP ($p<0.05$). According the results of post hoc analysis using the LSD procedure, significant differences in FVC, FEV_1, MIP, and MEP were observed for children with CP in the GMFCS level III group, compared with the other two CP groups. A significant difference in SVC was observed between the GMFCS level II and III groups.

DISCUSSION

In the current study, we found that children with CP who belonged to the GMFCS level III group had significantly lower respiratory function and respiratory pressure compared with the two other groups (i.e., GMFCS levels I and II). However, no significant difference was observed between children in the GMFCS level I and II groups. These results indicate that children with CP who walk with an assistive mobility device in most indoor settings have poor lung capacities and respiratory muscle weakness. Accordingly, it would be highly expected that children with CP who walk with an assistive mobility device in most indoor settings could have accompanying non-parenchymal pulmonary dysfunctions due to poor respiratory function and muscle weakness.

Decline of physical activity in pathologic conditions could lead to development of peripheral muscle abnormalities and dysfunction due to muscle weakness, increased muscle fatigue, and reduced oxidative capacity[11–14]. Several previous studies reported a close association of respiratory function and muscle strength with amount of daily living activities or functional exercise capacity in children with neurological disease[15, 16]. Therefore, our findings were supported by those of many previous studies, suggesting that deteriorated respiratory ability could be attributed to a decrease in functional activity due to abnormal movement and ambulatory function[15–17].

Our results showed a significant difference in respiratory function and respiratory pressure in the GMFCS level III group compared with the other two groups; the reason for this would be the difference in independent walking ability. According to functional GMFCS level, children categorized into GMFCS levels I and II had independent walking ability, whereas those categorized into GMFCS level III usually had some limitations in indoor environments that required use of self-support or walking-aid devices for independence[5]. Accordingly, we reasoned that children who could not walk independently would have low respiratory function and muscle strength due to a decline in lung capacity accompanied by limitation of functional movement. In addition, no significant difference between children categorized into GMFCS levels I and II in terms of respiratory function and muscle strengthening would be due to the fact that their capacities for physical activity were similar. This finding was supported by those of a previous study reporting that no difference in aerobic capacity was observed between GMFCS levels I and II in children with CP[18].

Physical function, such as cardiovascular fitness, is known to be closely related to respiratory function[19, 20]. In children, active physical activity accompanied by normal motor development is essential for growth of organs related to respiration in terms of respiratory muscles, lung parenchymal and airway structures. Our findings indicated that decrease in functional motor ability as classified by the GMFCS could be accompanied by respiratory function and respiratory muscle weakness. Therefore, careful evaluation of respiratory ability and its related muscle function will be required in cases of children with CP who have lower physical activity. We acknowledge that our study had the limitation of a small sample size, especially with respect to children classified into GMFCS level II. Further study will be needed for consideration of a larger sample size and various motor assessment variables.

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