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Original Article

Differences in respiratory pressure and pulmonary function among children with spastic diplegic and hemiplegic cerebral palsy in comparison with normal controls

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

[1)] *Department of Physical Therapy, Yeungnam University College, 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 purpose of this study was to determine differences in respiratory pressure and pulmonary function among children with spastic diplegic and hemiplegic cerebral palsy (CP) in comparison with children with normal development. [Subjects and Methods] Fourteen children with spastic diplegic CP, 11 children with hemiplegic CP, and 14 children with normal development were recruited. Respiratory pressure was measured and the pulmonary function test (PFT) was performed to evaluate the strength of the respiratory muscles and lung volumetric capacity. [Results] Regarding respiratory pressure, children with spastic diplegic and hemiplegic CP showed significantly lower functions in terms of MIP and MEP compared with children with normal development, although no significant differences were found between children with the two types of CP. In the pulmonary function test, children with spastic diplegic CP showed significantly higher pulmonary function than children with normal development in terms of only FVC and FEV_1. [Conclusion] Children with CP showed relatively lower function in terms of respiratory pressure and lung capacity, in comparison with children with normal development. Therefore, respiratory function in children with CP should be carefully evaluated and should receive more attention in a rehabilitation setting.

Key words: Respiratory pressure, Pulmonary function test, Cerebral palsy

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INTRODUCTION

Cerebral palsy (CP) is a neurological disorder commonly seen in pediatric rehabilitation. The disorder presents a group of neurological symptoms caused by nonprogressive brain lesions. The symptoms causing the most concern is motor dysfunction characterized by abnormality of muscle tone and movement pattern, poor postural control, motor developmental delay, and so forth[1, 2)]. Motor dysfunction causes limitation of functional activity and results in secondary complications related to the musculoskeletal system[3, 4)]. On account of this clinical importance, most rehabilitative treatments have intensively focused on recovery of motor function and compensation of residual physical capacity.

Many recent studies have revealed that children with CP are exposed to a risk of pulmonary dysfunction and parenchymal lung disease[5–8)]. Clinical symptoms consist of coughing and poor air clearance, decreased chest wall mobility, insufficient respiratory muscle function, etc[8, 9)]. These problems further deteriorate capacity for physical activity in daily life and are critical factors impeding recovery and development of motor function. Therefore, in this study, we attempted to examine how respiratory pressure and pulmonary function in children with spastic diplegic and hemiplegic CP differed from those in children with normal development.

SUBJECTS AND METHODS

Twenty-five children with spastic diplegic and hemiplegic CP as well as 14 children with normal development participated in this study. The inclusion criteria for recruitment of children with spastic CP were as follows: (1) diagnosis as spastic diplegic or hemiplegic CP by a pediatrician or pediatric neurologist based on brain MRI, (2) cognitive and language abilities sufficient to fulfill respiratory pressure and PFT, (3) group motor functional status classified as level I, II, or III of the GMFCS, and (4) no psychiatric or neurological disease except CP. The numbers of children with spastic diplegic CP (8 boys, age: 10.71±1.64) and hemiplegic CP (8 boys, age: 10.09±1.22) were 14 and 11, respectively. The numbers of children classified as levels I, II, and III of the GMFCS were 15, 6, and 4, respectively. Fourteen children

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

Table 1. Demographics, respiratory pressure, and pulmonary function test results for the three groups

		Diplegic CP	Hemiplegic CP	Normal children
Demographics	Age (years)	10.71±1.64	10.09±1.22	9.64±1.42
	Gender (male/female)	8/6	8/3	10/4
	BMI (points)	19.12±1.80	20.36±2.85	19.38±3.48
	BSA (m^2)	1.23±0.15	1.22±0.20	1.21±0.15
Respiratory pressure	MIP (cmH_2O)	30.64±13.51*	38.82±15.58†	86.93±15.48*†
	MEP (cmH_2O)	43.14±18.92*	48.82±15.28†	99.57±13.30*†
Pulmonary function test	FVC (l)	1.42±0.43*	1.58±0.57	1.83±0.25*
	FEV_1 (l)	1.26±0.45*	1.46±0.52	1.68±0.26*
	FEV_1/ FVC (%)	88.91±12.87	94.02±8.16	91.57±7.70
	PEF (l/sec)	2.63±0.73	3.08±1.42	3.40±0.78

*: significance at the $p<0.05$ level in comparisons between children with spastic hemiplegic CP and those with normal development,†: comparisons between children with spastic diplegic CP and those with normal development

with normal development (10 boys, age: 9.64±1.22) were sampled. They were matched to the following general characteristics that are already known to influence respiratory function: age, sex, body mass index (BMI), and body surface area (BSA). The parents of the children understood the purpose and safety of this study and gave written informed consent before experimental participation. The experimental protocol was approved by the local ethics committee.

All children were measured for respiratory pressure and pulmonary function test (PFT) in a sitting position on a chair with a backrest. The two measurements were carried out by the same tester in a counterbalanced manner throughout the entire experiment, and a sufficient rest period was provided. Respiratory pressure was assessed using a Micro Respiratory Pressure Meter (Micro Direct Inc., Lewiston, ME, USA). The maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP) were estimated as the measure of respiratory pressure based on the strength of the respiratory muscles. All children were instructed to breathe in or out against an occluded mouthpiece as forcefully as possible and with maximal effort while simultaneously keeping their lips sealed tightly around the mouthpiece. The equipment assessed the highest pressure that respiratory muscles could generate against an occlusion at the mouth.

The PFT was carried out using a spirometer (Vmax 229, SensorMedics, Yorba Linda, CA, USA), which acquired the forced vital capacity (FVC), forced expiratory volume at one second (FEV_1), ratio of forced expiratory volume at one second to forced vital capacity (FEV1)/(FVC), and peak expiratory flow (PEF). All children were instructed to breathe in and out through the mouthpiece as deeply and quickly as possible while their nose was occluded in a sitting position. The PEF was measured three times with enough rest between each trial to prevent hyperventilation. The best performance of the three trials was adopted.

For comparison of demographic data (age, sex, BMI, and BSA), respiratory function (MIP and MEP), and PET (FVC, FEV_1, FEV_1/FVC, and PEF) among the three groups (diplegic CP group, hemiplegic CP group, and normal control group), one-way ANOVA and the chi-square test were conducted. The Bonferroni procedure was used as a post hoc analysis for multiple group comparison. Statistical software, PAWS 18.0 (SPSS, Chicago, IL, USA), was used for analysis of all data, and statistical significance was considered at the level of $p<0.05$.

RESULTS

Table 1 shows general information and results for respiratory function of the children with spastic diplegic and hemiplegic CP and children with normal development, including demographic information (i.e., age, sex, BMI, and BSA), respiratory pressure (i.e., MIP and MEP), and PFT (i.e., FVC, FEV_1, FEV_1/FVC, and PEF). No significant differences in demographic variables were observed among the three groups in terms of age, sex, BMI, and BSA ($p>0.05$). Regarding respiratory pressure, children with normal development showed significant differences for MIP and MEP, compared with those with spastic diplegic and hemiplegic CP. No statistical differences were observed between children with spastic hemiplegic and hemiplegic CP. Regarding PFT, significant differences were found only in terms of FVC and FEV_1 in comparisons between children with normal development and those with spastic diplegic CP.

DISCUSSION

In this study, we compared the respiratory pressure and pulmonary function of children with spastic diplegic and hemiplegic CP with those of children with normal development. The results showed that the children with spastic diplegic CP showed significantly lower respiratory function in terms of MIP, MEP, FVC, and FEV_1 compared with children with normal development. For FVC and FEV_1, only children with spastic hemiplegic CP showed a significantly lower ventilation capacity than children with normal development. However, no significant differences were observed among the three groups in terms of FEV_1/FVC and PEF.

One viable explanation for the significant difference in respiratory pressure between children with spastic CP and those with normal development is that both diplegic and hemiplegic CP are characterized by paralysis of limb as well

as respiratory muscles. Neurological involvement of a group of muscles related to respiratory function in CP has already been well established by many prior studies[9–11]. According to the study of Lee and Kim[12], children with CP who can walk show better respiratory muscle strength than those who cannot walk. In the results of the PFT, only children with spastic diplegic CP showed a significant difference compared with children with normal development. These findings corroborate results reported in several previous studies[6, 9, 13], which have shown that children with CP, in particular in diplegic CP, have a significantly lower outcome in the PFT in comparison with children with normal development. The reason for this relative decrease in functional lung capacity in children with CP is inefficiency of cardiovascular fitness and chest mobility caused by neurological disorder. In the comparisons of respiratory pressure and PFT between children with the two types of CP, the children with hemiplegic CP generally showed better function in all variables, even if nonsignificant findings were observed. Our previous study indicated that children with hemiplegic CP showed significantly higher forced expiratory function, compared with children with normal development[6].

Respiratory function is vital to maintenance of cellular metabolism for maintenance of life. Recent studies have suggested that children with CP show respiratory dysfunction related to multiple neuromuscular symptoms, such as paralysis of respiratory muscles, limited chest expansion, inefficient biomechanics of breathing structures, and abnormal neuromotor development[11, 13–19]. Therefore, understanding the respiratory functional level of children with CP will be important for clinical assessment and therapeutic intervention in rehabilitation. We expect that our findings will help develop clinical guidelines for rehabilitative specialists to be used in evaluation of respiratory function in children with CP. However, the results of this study may be difficult to generalize due to the small sample size. Thus, further studies investigating clinical factors related to CP will be needed with a larger sample size.

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