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Original Article

Comparison of pulmonary function and back muscle strength according to the degree of spinal curvature of healthy adults

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Abstract. [Purpose] Degree of curvature on the spine is known to affect respiratory function and back muscle activation. We compared pulmonary function and back muscle strength according to the degree of curvature of the spine of healthy adults. [Subjects and Methods] Twenty-three healthy volunteers were enrolled. They were divided into two groups according to the degree of curvature of the spine: the below 2° group, and the above 2° group. The degree of curvature was assessed using the Adams forward bending test and a scoliometer. A pulmonary function test (PFT) was conducted, and back muscle strength was measured. [Results] No significant differences in PFT were found between the below 2° group and the above 2° group, in terms of forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), ratio of forced expiratory volume in one second to forced vital capacity (FEV_1/FVC), or peak expiratory flow (PEF). However, back muscle strength in the below 2 group was significantly higher than that of the above 2 group. [Conclusion] Our findings indicate that the degree of curvature of the spine is associated with back muscle strength in subjects who have spinal curvature within the normal range. Therefore, evaluation and treatment of back muscle strength might be helpful for preventing the progress of curvature of the spine in adolescents with potential scoliosis.
Key words: Scoliosis, Pulmonary function, Back muscle strength

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INTRODUCTION

Scoliosis is a 3-dimensional abnormal curvature of the spine, and is the most common deformity of the spine[1)]. Its causes include neurological or neuromuscular dysfunction in cerebral palsy, Duchenne myopathy, medullary lesion, and others[2)]. However, even though the main causes of most scoliosis cases are unknown, it can be classified as a congenital factor by vertebral or rib malformation, a secondary factor by systemic or neuromuscular disorders, and idiopathic by no specific cause[3)]. The prevalence reported by previous studies varies from 0.3 to 15.3%[4–7)]. The criterion for scoliosis is generally defined as a spinal curvature of 10 degrees in the sagittal plane[8)].

Most researchers who have studied pulmonary dysfunction in patients with scoliosis agree that there is a possibility of cardiorespiratory failure in cases with a Cobb angle greater than over 90 degrees, lung function abnormalities when the Cobb angle is in the range of 50 to 60 degrees, and that there is correlation of the severity of abnormal curvature and pulmonary function[3, 9)]. In addition, accumulating evidence indicates that abnormal curvature of the spine is affected by asymmetry of the back musculatures[2, 10, 11)]. Likewise, abnormality of spinal curvature has a strong effect on pulmonary function and back muscle activation. However, to the best of our knowledge, few studies have investigated the relationship between pulmonary function and asymmetry according to the degree of curvature of the spine in normal adolescents[12)].

Therefore, the purpose of this study was to investigate whether or not there are any differences in pulmonary function and back muscle strength according to the degree of curvature of the spine of healthy adults.

SUBJECTS AND METHODS

Twenty-three healthy subjects with no previous history of neuromuscular or neurologic dysfunction participated in this study. They understood the purpose of this study, and gave their written informed consent before experimental participation. The experimental protocol was approved by the ethics committee of Daegu University. The subjects were divided according to the angular degree of their spinal curvature: into two groups, the below 2 group (9 males, 4 females, age: 23.2±2.1) and the above 2 group (4 males, 6 females, age: 23.5±2.0).

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The degree of spinal curvature was measured using a scoliometer (National Scoliosis Foundation, Watertwon, MA, USA) in the Adams forward bending test. The Adams forward bending test was used to evaluate the rib hump forms on the side of the convexity. All subjects were instructed to bend forward, starting at the waist until the back became horizontal, with the feet together, arms hanging and the knees in extension. The examiner stood at the back of the subject and measured the degree of rib hump in the horizontal plane of the spine using the scoliometer.

The pulmonary function test (PFT) was performed by all participants. The PFT was measured using a spirometer (Vmax 229, SensorMedics, USA), which calculated and recorded forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), ratio of forced expiratory volume in one second to forced vital capacity (FEV_1)/(FVC), and peak expiratory flow (PEF). The subjects sat in a chair with a backrest and were instructed to breathe in as deeply as possible, and then breathe out through a mouthpiece as quickly as possible, with their noses occluded. The measurement was performed by the same tester throughout the entire experiment, and was performed two times with enough rest between each trial to prevent hyperventilation. The best performance of three trials was adopted.

Back muscle strength test was assessed using a muscle strength meter (TKK 5102, Takei Co., Japan). Before the test, the length from the handle to the footplate was adjusted so that the subject could reach the handle when the subject bent his/her back by 30 in the standing position with his/her heels together and the toes 15 cm apart. In this position, the subject was asked to extend his/her back gradually, increasing his/her strength. The back muscle strength was measured twice in kilograms. The best performance of two trials was adopted.

For comparison of demographic data (i.e., age, sex, height, weight, degree of curvature), PFT (FVC, FEV_1, FEV_1/FVC, and PEF), and back muscle strength between the two groups, the independent t-test and the χ^2 test were conducted. Statistical software, PAWS 18.0 (SPSS, Chicago, IL, USA), was used to analyze the data, and statistical significance was accepted at values of $p<0.05$.

RESULTS

The degree of curvature of the spine of all subjects was below 5. No significances were found, in terms of age, gender, height, or weight in the comparison of demographic data between the two groups (Table 1). However, the degree of curvature in the above 2 group was significantly greater than that of the below 2 group. For PFT, no significant results were found between the two groups, in terms of FVC, FEV_1, FEV_1/FVC, or PEF. In the test of back muscle strength, a significant difference was found between the two groups (Table 2).

DISCUSSION

In the current study, we compared pulmonary function and back muscle strength according to the degree of curvature of the spine of healthy subjects who had spinal curvature within the normal range. We adopted 2 of spinal curvature as the cutoff point, because it clearly discriminated between the two-cluster distribution of the scatter plot showing the degree of spinal curvature of all the subjects. The muscle strength of the back musculatures of the below 2 group was significantly stronger than that of the above 2 group. However, the pulmonary function of the above 2 group and the below 2 group showed no significant difference, in terms of FVC, FEV_1, FEV_1/FVC, and PEF. Therefore, our results suggest that the degree of curvature of the spine within the normal range directly affects back muscle strength, but not pulmonary function.

Many previous studies have reported that abnormal curvature of the spine has a negative effect on pulmonary function in various ways, including cardiorespiratory impairment, decrease in lung volume, and chest wall movement[3, 10, 11, 13–16]. These possible items of pulmonary dysfunction are suggested to be caused by thoracic deformity due to abnormality of the spinal curvature[17]. However, our findings show that the degree of spinal curvature did not negatively affect pulmonary function. Tsiligiannis and

Table 1. Demographic information of the two groups

	Below 2° group	Above 2° group
Age (years)	23.2±2.1	23.5±2.0
Gender (M/F)	13 (9/4)	10 (4/6)
Height (cm)	169.9±8.9	165.6±4.2
Weight (kg)	67.1±9.4	60.7±7.9
Degree of curvature (°)	0.8±0.3	3.0±1.5

Values are expressed as frequencies or means ± standard deviation.

Table 2. Pulmonary function and back muscle strength of the two groups

		Below 2° group	Above 2° group
Pulmonary function test	FVC (l)	5.2±2.2	4.9±2.0
	FEV_1 (l)	4.43±1.4	3.8±1.9
	FEV_1/ FVC (%)	0.8±0.2	0.8±0.3
	PEF (l/sec)	8.5±2.2	7.3±2.8
Back muscle strength	(kg)	99.5±39.8*	68.1±26.4

* indicates a significance difference ($p<0.05$) between the results of the below 2 group and the above 2 group.

Grivas suggested that mild to moderate scoliosis actually produced very few respiratory signs and symptoms[3]. In addition, Redding and Mayer reported that some measurements that are often used, such as the Cobb angle are not related to pulmonary function[18]. Taken together, these results strongly suggest that the degree of spinal curvature within the normal range is not associated with pulmonary function.

The significant finding in the comparison of back muscle strength according to the degree of spinal curvature is in agreement with previous[19–22]. Several studies have reported that strength asymmetry is observed in patients with scoliosis due to the difference in the ratio of the convex and concave angles of the spine[22–25]. Mooney et al.[25] proposed that inhibition of the paraspinal muscles by abnormal curvature of the spine might be a cause of weak trunk muscle function, which is known to contribute about 5% of the total torque involved in trunk rotation[26]. Stiff spine, trunk strength and asymmetry might occur, due to abnormal curvature of the spine causing abnormal muscle geometry, and ligament deformity[22].

Abnormal structure of the spine in the sagittal and frontal planes affects progressive deformity of the spine and thoracic rib cage, cardiorespiratory function, low back pain, and neurologic complications[3]. Therefore, multiple impairments related to abnormal curvature of the spine need to be considered carefully when treating patients with abnormal structure of the spine. Our findings suggest that the degree of spinal curvature is associated with back muscle strength, not with respiratory function, in individuals with normal spinal curvature. However, limitations of this study are that radiographic measurement of the degree of spinal curvature was not performed, and that no comparisons with patients with scoliosis were presented. In further study, these limitations will be addressed to elucidate clinical features related to the degree of spinal curvature.

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