J. Phys. Ther. Sci.
25: 1629–1631, 2013

The Effect of Scoliosis Angle on Center of Gravity Sway

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Abstract. [Purpose] The purpose of this study was to verify the effects of idiopathic scoliosis on the human body by comparing the postural balance of adolescents with and without idiopathic scoliosis, to provide basic data for the optimal desirable growth and development of adolescents. [Subjects] The subjects were 128 adolescents diagnosed with scoliosis on X-ray by orthopedists. The subjects were divided into a 10 to 19 degree group, 20 to 29 degree group, and 30 degree and over group according to the degree of scoliosis. For comparison, 15 normal adolescents without orthopedic injury within the last 6 months were selected as a control group. [Methods] As measurement tools, DK2 525R (Dongkang Medical: Korea) was used to measure the Cobb angle and a multifunktional training-geraete device (MFT, Germany) was used to measure balance. One-way variance of analysis was conducted in order to examine differences among the four groups in left and right balance, forward and backward balance, and overall postural balance, and when there were differences, they were compared in detail using Duncan's post-hoc test. [Results] The results of scoliosis angle and body mass index (BMI) showed significant differences between the normal group (NG) and the scoliosis groups (GI, G II, G III), but there were no significant differences among the scoliosis groups. The scoliosis groups showed a significantly lower BMI than that of the normal group. In addition, the results of the left/right and the front/rear balance abilities showed significant differences between the normal group and the scoliosis groups. Furthermore, the results of whole body balance ability were showed significant differences between the normal group and the scoliosis groups.

Key words: Scoliosis, Gravity sway, Postural

(This article was submitted Jun. 3, 2013, and was accepted Jul. 5, 2013)

INTRODUCTION

Scoliosis is a three dimensional deformation resulting from axial rotation of the vertebrae and is defined as a lateral spinal curvature with a Cobb angle of 10 degrees or more[1)]. Scoliosis is classified into an infantile type that appears before the age of 3, a juvenile type that appears at ages between 3 and 10, an adolescent type from the age of 10 when the musculoskeletal system growth is almost complete, and an adult type after the musculoskeletal system growth has been completed. About 80% of scoliosis is idiopathic, and the incidence rate of idiopathic scoliosis is increasing in adolescents across the world[2)]. Idiopathic scoliosis is a progressive growth disease that severely affects the anatomical structure of the spine, range of motion, and left and right asymmetry[3)]. This condition is observed much in adolescence when the growth of the musculoskeletal system is more vigorous than that of the muscle growth, and genetic factors, collagen metabolism, and abnormality in the vestibular system, and imbalance and weakening of the muscles aggravate its symptoms[4)]. Guo et al.[5)] noted that idiopathic scoliosis patients in their adolescence exhibit balance and gait characteristics different from those of healthy subjects and this should be considered in the initial diagnosis of scoliosis patients; If a precise clinical examination of the characteristics of idiopathic scoliosis is made and subject are appropriately educated, about precautions to take in their daily lives, great advances could be made in the prevention and treatment of scoliosis. Accordingly, this study aimed to clearly understand the effects of idiopathic scoliosis on the body's balance ability to provide basic evidentiary material for the optimal growth and development of adolescents by comparing degrees of idiopathic scoliosis and postural balance of adolescents.

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SUBJECTS AND METHODS

The subjects of this study were 128 adolescents who were diagnosed with scoliosis on X-ray by orthopedists among those who visited B hospital located in S region. The subjects were divided into a 10 to 19 degree group, 20 to 29 degree group, and 30 degree and over group according to the degree of scoliosis. For comparison, 15 normal adolescents without orthopedic injury within the past 6 months were selected as a control group. The subjects were divided into four groups: Group I had a Cobb angle between 10 and 20 degrees, Group II had a Cobb angle between 20 and 30 degrees, and Group III had a Cobb of 40 degrees or higher, and the normal group. The normal group (NG) group (n=15) was 14.70 ±1.70 years old in age, had a height of 1.60±0.06 cm, a weight of 65.20±10.37 kg, a BMI of 22.8±2.69, and a Cobb angle of 1.0±0.11 degrees. The I group was 15.50±1.78 years old in age, had a height of 1.60±0.06 cm, a weight of 51.20±9.12 kg, a BMI of 19.3±2.61, and a Cobb angle of 13.7±2.63 degrees. The II group was 15.10±1.64 years old in age, had a height of 1.60±0.06 cm, a weight of 47.30±8.11 kg, a BMI of 18.30±2.85, and a Cobb angle of 23.9±3.23 degrees. The III group was 15.50±1.85 years old in age, had a height of 1.60±0.07 cm, had a weight of 50.0±8.54 kg, a BMI of 19.0±2.44, and a Cobb angle of 36.40±5.79 degrees.

A DK2 525R (Dongkang Medical: Korea) was used to measure the Cobb and a multifunktional traininggeraete device (MFT, Germany) was used of the Spine balance. The curvature to measure was determined from the upper and lower ends. One line was drawn to the spinal upper end of the upper part and the other line was drawn to the lower end. Lines were drawn from each line at right angles and the angle of their intersection was measured as the degree of scoliosis[6]. The MFT balance tester (MFT balance test-basic, Multifunktionale trainsgerate, Germany) consists of a force plate and a visual target program. The subjects' balance abilities were measured twice, the adaptation stage and actual measurement, in the forward, backward, left, and right directions according to the measurement protocol. In order to measure balance ability without shoes, subjects' balance abilities were measured with them standing in bare feet as well. The target of the balance ability test is a circle which is divided into sections 1, 2, 3, 4, and 5 from the center. The subjects were encouraged to locate their center of gravity at the center of the target, and the areas where the center is located during 30 seconds are calculated as Percentages of the whole. Left and right balance and forward and backward balance were derived from the absolute values by subtracting the rate of the opposite direction from the rate of the selected direction, and dynamic balance was calculated using a right-angled triangle that drawn by locating the absolute value of left and right balance to the X-axis, and the absolute value of the forward and backward balance to the Y-axis, on a two-dimensional plane and connecting the two points. One-way variance of analysis was conducted in order to examine differences among the four groups in left and right balance, forward and backward balance, and overall postural balance. When there were differences, they were compared in detail using Duncan's post-hoc test. The statistical significance level was chosen as 0.05. All the participants understood the purpose of this study and provided their written informed consent prior to their participation in the study in accordance with the ethical standards of the Declaration of Helsinki.

Table 1. Comparison of BMI between the groups

No	Group	M±SD (kg/m^2)
1	NG (n=15)	22.83± 2.69
2	GI (n=57)	19.31± 2.61
3	GII (n=34)	18.33± 2.85
4	GIII (n=37)	19.02± 2.44

NG: normal group (Cobb angle below 10°)
GI: group I (Cobb angle 10–19°)
GII: group II (Cobb angle 20–29°)
GIII: group III (Cobb angle above 30°)

Table 2. Comparison of left and right balance between the groups

No	Group	M±SD (kg/m^2)
1	NG (n=15)	2.38± 1.96
2	GI (n=57)	12.57± 9.55
3	GII (n=34)	13.47±11.54
4	GIII (n=37)	12.33±10.68

G: normal group (Cobb angle below 10°)
GI: group I (Cobb angle 10–19°)
GII: group II (Cobb angle 20–29°)
GIII: group III (Cobb angle above 30°)

Table 3. Comparison of forward and backward balance between the groups

No	Group	M±SD (kg/m^2)
1	NG (n=15)	10.37± 8.51
2	GI (n=57)	20.44±12.91
3	GII (n=34)	22.14±18.03
4	GIII (n=37)	16.28±11.43

NG: normal group (Cobb angle below 10°)
GI: group I (Cobb angle 10–19°)
GII: group II (Cobb angle 20–29°)
GIII: group III (Cobb angle above 30°)

Table 4. Comparison of postural balance between the groups

No	Group	M±SD (kg/m^2)
1	NG (n=15)	10.37± 8.51
2	GI (n=57)	20.44±12.91
3	GII (n=34)	22.14±18.03
4	GIII (n=37)	16.28±11.43

NG: normal group (Cobb angle blow 10°)
GI: group I (Cobb angle 10–19°)
GII: group II (Cobb angle 20–29°)
GIII: group III (Cobb angle above 30°)

RESULTS

As shown in Table 1, differences in body mass index (BMI) between the groups were examined and the normal group's BMI was higher at 22.83±2.69 than those of the scoliosis groups, and the difference was very statistically significant ($p<0.001$). In particular, the scoliosis group's BMI was less than 20, which meant that their weight was relatively small compared to their height. According to the posthoc test result, there were no differences among the scoliosis groups but their BMI was smaller than that of the normal group. As shown in Table 2, differences in lateral balance between the left side and the right side were examined, and there were statistically significant differences among the groups ($p<0.01$). According to the posthoc test result, there were no difference among the scoliosis groups, but the scoliosis groups' left and right lateral balance was unstable compared to the normal group. As shown in Table 3, differences in forward and backward balance among the groups were examined, and there were statistically significant differences among the groups ($p<0.01$). According to the post-hoc test result, there were no differences between the scoliosis groups but the scoliosis group's forward and backward balance was more unstable than the normal group's. As in Table 4, differences in postural balance between the groups were examined and there were statistically significant differences between the groups ($p<0.01$). According to the result of the posthoc test, there were no difference between the scoliosis groups but the scoliosis groups' forward and backward balance was more unstable than that of the normal group.

DISCUSSION

Today, with the advent of the information society, physical activities have decreased and sedentary lifestyles have rapidly increased the number of cases of spinal diseases, which are becoming a social problem[7]. Accordingly, this study systematically examined differences in postural balance according to the degree of adolescents' idiopathic scoliosis and discusses treatment for them.

In a previous study of the relationship between scoliosis and balance ability, Nault et al.[8] reported that mobility of weight and the center of pressure were considerably higher in the scoliosis group than in the normal group, and the reason for this was that compensation occurred in the muscular system to maintain static balance due to the characteristics of unstable postural balance. In other words, when adolescents with idiopathic scoliosis sit in a wrong position, the unbalanced weight load on the upper body affects the arrangement and angle of the spine. Guo et al.[5] noted that scoliosis patients were abnormal in a one-sided somatosensory evoked potential test, and that their balance control ability was abnormal. The present study compared the balance ability of normal students and students with scoliosis, and there were significant differences between the two groups in right and left balance, forward and backward balance, and whole body balance. The results of the present study are consistent with those of by Simoneau[9] who reported there were differences between a normal group and scoliosis patients in the visual sense and somato-sense. Summarizing the results of previous studies and the present study, a major cause of scoliosis is asymmetric posture of the trunk, decrease in physical activity, is a major risk factor for scoliosis, and a larger Cobb angle, is associated with a larger deviation from balance.

According to previous studies, patients with moderate scoliosis early examination and scoliosis risk factors, and 3 to 22 percent of curvatures of larger than 5 degrees naturally disappeared through efforts to correct the posture and self-exercise after they had been diagnosed[10]. Most of those with Hawthorne effect had a curvature of less than 10 degrees. Follow-up research will be necessary to verify differences in postural habits according to the degree of adolescent idiopathic scoliosis. Also, research to examine multidimensional causes that affect the psychological and social characteristics of adolescents and to develop effective rehabilitation programs for adolescents with idiopathic scoliosis as well as to verify their effects will be needed.

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