Vol. 11, No. 1, pp. 22-25, June 2012

INTERNATIONAL
JOURNAL OF SAFETY
www.kosos.or.kr

A Study on Asymmetric Lifting Capacity Due to Spine Deformity

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(Received February 21, 2012; Accepted June 5, 2012)

Abstract : Scoliosis can be biomechanically described as a three dimensional deformity of the spine, with deviations from the physiologic curves in the sagittal and frontal planes, usually combined with intervertebral rotation. Various factors are suspected such as genetic defects, uneven growth of the vertebrae, hormonal effects, abnormal muscular activity, postural problems, or a mix of some of these elements, but its initial cause is known in only 15-20% cases. The screening test for diagnosing scoliosis is called the Adams Forward Bend Test. During the experiment, the subjects were asked to bend over, with arms dangling, until a curve could be observed. The Scoliometer was placed on the back of the subjects and used to measure the difference between the left and right apex of the curve in the thoracic, thoracolumbar and lumbar area. Then, the subjects were asked to perform Maximum Voluntary Contractions (MVCs) using the digital back muscle dynamometer in three different postures: (1) 0o (sagittally symmetric); (2) 30o from the mid-sagittal plane (clockwise); and (3) 30o from the mid-sagittal plane (counter-clockwise). In addition to the experimental data, subject-dependent variables including Body Mass Index (BMI), percentage of body fat and muscle mass of left/right arms and legs were employed to reveal the cause of difference among three MVC conditions. All those variables were tested using statistical methods.

Key words : asymmetric lifting capacity, dynamometer, maximum voluntary contractions, scoliometer, scoliosis

1. Introduction

Scoliosis can be biomechanically described as a three dimensional deformity of the spine, with deviations from the physiologic curves in the sagittal and frontal planes, usually combined with intervertebral rotation [1]. Various factors are suspected such as genetic defects, uneven growth of the vertebrae, hormonal effects, abnormal muscular activity, postural problems, or a mix of some of these elements, but its initial cause is known in only 15-20% cases [2-5]. While a normal spine appears straight when seen from behind, a scoliotic spine appears “S” or “C” shaped [6].

The screening test for diagnosing scoliosis is called the Adams Forward Bend Test [7]. In this test, the presence of any visible asymmetry is often quantified by measuring the angle of trunk rotation. This is the angle between the horizontal plane and the line across the back going through the point with maximum deformity. The Angle of Trunk Rotation (ATR) is usually estimated with a surface measuring device called a scoliometer [8] which shows the following results: (1) over 3 degrees in ATR: 80%; (2) over 5 degrees in ATR: 12% (referral criterion); and (3) over 7 degrees in ATR: 3% [9]. If the ATR is over 5 degrees, an X-ray could be employed to capture the Cobbís angle. Over 10 degrees in the Cobbís angle denotes scoliosis [10-11]. Even though the scoliometer measurements are not considered accurate and reliable enough to guide scoliosis treatment, the instrument is still useful as a tool for preliminary diagnosis and further X-ray referral [12]. Also, it is well-known that the device guarantees good intrarater and interrater reliability in scoliosis screening examinations [13]. Based on these facts, this study will be used to measure the ATR using the scoliometer in the thoracic, thoracolumbar and lumbar region, and the results will be used to investigate the effects of scoliosis on the asymmetric lifting capacity.

2. Matrial and Method

The scoliometer in Fig. 1 was used to capture ATR. During the experiment, the subjects were asked to bend over, with arms dangling, until a curve could be

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Fig. 1. The screening test for diagnosing scoliosis using the scoliometer.

observed. The Scoliometer was placed on the back of the subjects and used to measure the difference between the left and right apex of the curve in thoracic (T4-T8), thoracolumbar (T12-L1) and lumbar (L3-L5) area [14]. The right value in the degree of ATR measured by the scoliometer was deemed plus (+), the left value was deemed minus (-) [14]. Then, the ATR data was subdivided into the three groups: (1) 0 ($-1 \le$ degree of ATR $\le +1$); (2) -1 (degree of ATR ≤ -2); (3) +1 (degree of ATR $\ge +2$).

A reference frame designed to fix the rotation of the pelvis was used, and the digital back muscle dynamometer (Takei kikikogyo Co., Ltd.) was used to measure the maximum voluntary contractions (MVCs). Three different postures were assumed to measure the MVCs: (1) 0^o (sagittally symmetric); (2) 30^o from the mid-sagittal plane (clockwise); and (3) 30^o from the mid-sagittal plane (counter-clockwise) (Fig. 2).

All three postures were replicated three times (total 9 trials), and the subjects had a ten minute break between each trial. Also, all of the trials were totally randomized.

Finally, the data was further processed by calculating the differences from counter-clockwise 30^o MVCs to clockwise 30^o MVCs.

Fig. 2. Three different postures for measuring the MVCs.

Fig. 3. The body composition analysis device.

Additional data was collected using the body composition analysis device (T-scan plus, Jawon medical Co., Ltd.), including body mass index (BMI), percentage of body fat and muscle mass of left/right arms and legs, in order to analyze the effect of body composition on the asymmetric lifting capacity (Fig. 3).

The BMI and percentage of body fat were used to divide the subjects into the following three groups: (1)

In total, 24 male college students participated in this study (age: 24.29±1.49; height: 173.73±5.45 cm; weight: 71.48±8.41 kg). There were twenty-one right-handed subjects and three left-handed subjects.

The data was analyzed using the Minitab software to perform the correlation analysis and one-way ANOVA. The Post-Hoc test (multiple comparisons) using the Tukey Method was employed. The significant level was assumed as $p < 0.05$.

3. Result

The results of correlation analysis between counter-clockwise 30^o and clockwise 30^o MVCs have been summarized in Table 1.

The degree of ATR in all three spinal regions showed

Table 1. The body composition analysis device.

	correlation coefficient	p-value
BMI	-0.116	0.591
Percentage of body fat	-0.153	0.475
Muscle mass of arms	-0.253	0.232
Muscle mass of legs	-0.208	0.328
ATR of Thoracic	0.676	<0.001**
ATR of Thoracolumbar	0.693	<0.001**
ATR of Lumbar	0.622	0.001**

*significant at 0.05 level; **significant at 0.01 level

Table 2. Result of one-way ANOVA for degree of ATR.

	Mean±StDev	F-value	p-value
Thoracic	-1: -0.80±0.81 0: 0.89±1.23 1: 1.84±0.42	12.39	<0.001**
Thoracolumbar	-1: -0.50±0.95 0: -0.28±1.25 1: 1.64±0.82	13.65	<0.001**
Lumbar	-1: -0.90±0.98 0: 0.38±1.12 1: 1.24±1.38	4.52	0.023*

*significant at 0.05 level; **significant at 0.01 level

significant correlation, but all others showed no correlation. The results suggested that the muscle mass in the legs and arms does not have any influence on the asymmetric lifting capacity.

The results of one-way ANOVA showed no effect of BMI and percentage of body fat on the difference between counter-clockwise 30° and clockwise 30° MVCs (F-value 0.00, 2.78 (p-value 0.966, 0.085), respectively).

Also, the results of one-way ANOVA showed significant effects of degree of ATR in all three spinal regions (thoracic, thoracolumbar and lumbar) on the difference between counter-clockwise 30° and clockwise 30° MVCs (see Table 2).

The Post-Hoc test results using the Tukey Method have been summarized in Table 3. The paired comparisons between group -1 and group 1 showed significant mean difference in all three spinal regions. The results denote that if the degree of ATR showed negative values the clockwise 30° MVCs is bigger. Similarly, if the degree of ATR showed positive values the counter-clockwise 30° MVCs is bigger.

Table 3. Result of Tukey test for degree of ATR.

	Paired comparison	95% CI		
		Lower	Center	Upper
Thoracic	(-1)↔(0) *	0.54	1.69	2.85
	(-1)↔(1) *	1.22	2.64	4.06
	(0)↔(1)	-0.39	0.95	2.29
Thoracolumbar	(-1)↔(0)	-1.16	0.22	1.60
	(-1)↔(1) *	1.01	2.14	3.26
	(0)↔(1) *	0.61	1.92	3.22
Lumbar	(-1)↔(0)	-0.54	1.28	3.10
	(-1)↔(1) *	0.33	2.14	3.96
	(0)↔(1)	-0.51	0.86	2.23

*significant mean difference

The difference in the three groups (e.g., -1, 0 and 1) on three different spinal regions such as thoracic, thoracolumbar and lumbar area was presented in Fig. 4, 5 and 6 as Boxplots.

The figures showed an increasing trend of MVCs from group -1 to group 1 in all three spinal regions including thoracic, thoracolumbar and lumbar area. So, it is plausible to conclude that the scoliosis in thoracic, thoracolumbar and lumbar area can influence the lifting capacity according to the direction of spinal deformity.

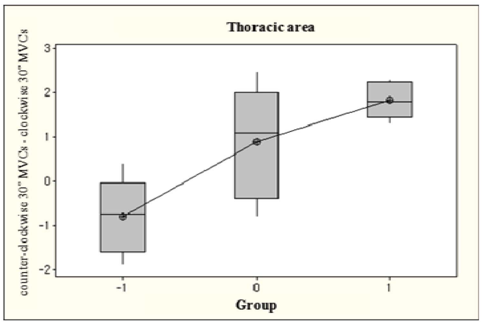

Fig. 4. The box plot of difference between counter-clockwise 30° MVCs and clockwise 30° MVCs by Thoracic are.

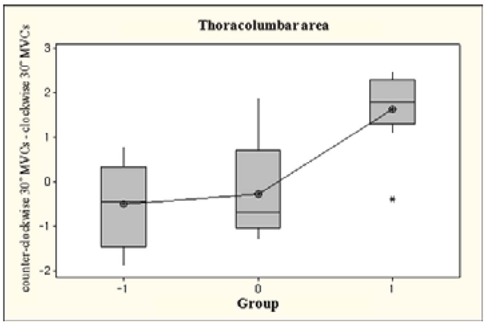

Fig. 5. The box plot of difference between counter-clockwise 30° MVCs and clockwise 30° MVCs by Thoracolumbar area.

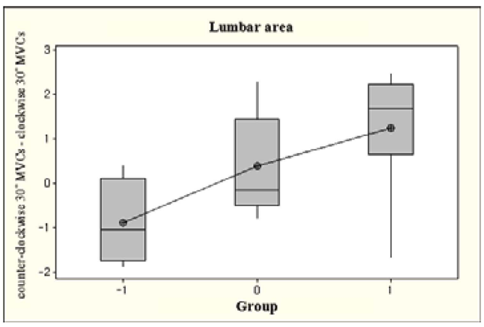

Fig. 6. The box plot of difference between counter-clockwise 30° MVCs and clockwise 30° MVCs by Lumbar area.

4. Discussion

The goal of this study was to investigate the effects of scoliosis on the asymmetric lifting capacity. The results suggested a significant effect of scoliosis on asymmetric lifting capacity. There are several limitations of this study that influence the generalizability of results. First, the participants in this study were physically fit, young college students. So, if the tests were performed on the general population, the results could vary. Second, the number of participants was relatively small. The follow up study should recruit a larger number of participants in order to generalize the results. Third, the Electromyography (EMG) Technique should be used to further confirm the results of this study. Also, this study recruited most of the subjects with weak spinal deformity showing below 5 to 7 degrees of ATR. So, the future study with scoliosis patients will show a clear trend of spinal deformity.

Also, Cobb's angle captured by the X-ray will guarantee a more precise result in the influence of scoliosis on the asymmetric lifting. This type of study will test the effect of spinal deformity shapes such as "S" or "C" on asymmetric lifting capacity.

5. Conclusion

This study revealed no effects of BMI, percentage of body fat and muscle mass of left/right arms and legs on asymmetric lifting capacity. However, it should be denoted that the degree of ATR in the thoracic, thoracolumbar and lumbar area influences the asymmetric lifting capacity. For example, if the right side of the spine is higher in the Adams Forward Bend Test, then the clockwise lifting capacity is better than the counter-clockwise lifting capacity. Similarly, if the left side of the spine is higher in the Adams Forward Bend Test, then the counter-clockwise lifting capacity is better than the clockwise lifting capacity. Based on these results, we can conclude that the asymmetric lifting capacity could be influenced by the spinal deformity direction.

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