COMPARISON OF GAIT ANALYSIS BETWEEN ADOLESCENT IDIOPATHIC SCOLIOSIS PATIENTS AND AGE MATCHED CONTROLS

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The purpose of this study was to compare kinematic variables and surface EMG values between adolescent idiopathic scoliosis patients and age matched controls during a gait. Six male patients and five male healthy subjects were recruited for this study. Six cameras were used for 3D motion capture and selected joint angles were computed. Eight pairs of surface EMG electrodes were placed on latissimus dorsi, psoas, glutaeus medius, and biceps femoris. Results revealed that the scoliosis patients showed smaller hip joint angles compared to the values of the controls and vice versa for the trunk tilting angle. Small EMG activity of latissimus dorsi also found from the patient group. This meant that the scoliosis clearly influenced to the abnormal posture during a gait. Such results may be helpful to develop rehabilitation exercise or device.

KEY WORDS: spine deformation, posture, walking, kinematics, electromyography.

INTRODUCTION: Scoliosis is the deformity of the spine that translates laterally with twist at the central axis of rotation. This disorder was frequently appeared in adolescent because growth rate of musculoskeletal system was very rapid in this age (Skaggs & Bassett, 1997).
Poor posture and spine deformations are neglected until the physical symptoms caused such as back pain, chest pain, dyspnoea during exercise, and appearance have become severe problems and are discovered by accident. Although early detection is crucial for treatment which is to stimulate to normal growth and good posture, the majority of cases are discovered after long progression of the disease (Park, Lee, & Kim, 2008). It is well known that the earlier the detection of any musculoskeletal problems then the rate of a successful treatment is substantially higher and treatment thus less evasive. (Eden-Kilgour & Gibson, 1990; Francis & Bryce, 1987). The relationship among abnormality of vertebral body alignment (scoliosis, kyphosis), low back pain, and musculoskeletal disorders has been well established. In the worst cases, scoliosis may even damage internal organs like the lungs which can result in respiratory failure and eventually leads to abdominal surgery.
Therefore, the purpose of this study was to investigate how the scoliosis may influence to the selected kinematics and muscle activities during gait. This study also provides useful information to develop rehabilitation excise program or functional garment for scoliosis patients.

METHODS: Six patients idiopathic scoliosis with 20° or less of Cobb's angle (17 ±1.1 y, 174 ±7.3 cm, 56.7 ±8.7 kg) and five normal subjects (14.4 ±0.5 y, 170 ±6.2 cm, 61.9 ±20.9 kg) were selected for this study. Six high-speed infrared cameras (Motionmaster 100, Visol, Korea; 120 Hz) with Kwon3D software were used for 3D motion analysis.
Eight pairs of surface electrodes (Delsys Trigno wireless system, USA; 2000 Hz) were placed on the left and right latissimus dorsi, psoas, gluteus medius, and bicep femoris for Electromyography (EMG) analysis. A trigger module was used to synchronize between cameras and EMG system. The DLT algorithm was used to calculate 3D coordinate values. Raw 3D data were filtered with Butterworth low pass filter (6 Hz) and then used to compute hip joint inclination angle and shoulder tilting angle. EMG data were collected from the standing posture for reference EMG and during gait for 5 s. The raw EMG signals were

filtered using Butterworth band pass filter (5-500 Hz) and normalized with reference EMG as % reference voluntary contraction (RVC) (Lehman & McGill, 1999).
Seven events and 6 phases during a gait were identified for further analysis (Figure 1): the left foot heel strike to the ground (LHS), the right foot toe off the ground (RTO), the left foot mid-stance during a support phase (LMS), the right foot heel strike to the ground (RHS), the left foot toe off the ground (LTO), the right foot mid-stance during a support phase (RMS), the second left foot heel strike to the ground (LHS2). Each phase consisted of adjacent two events. Independent t-test using SPSS 18.0 was conducted to verify the differences between scoliosis patient group and control group.

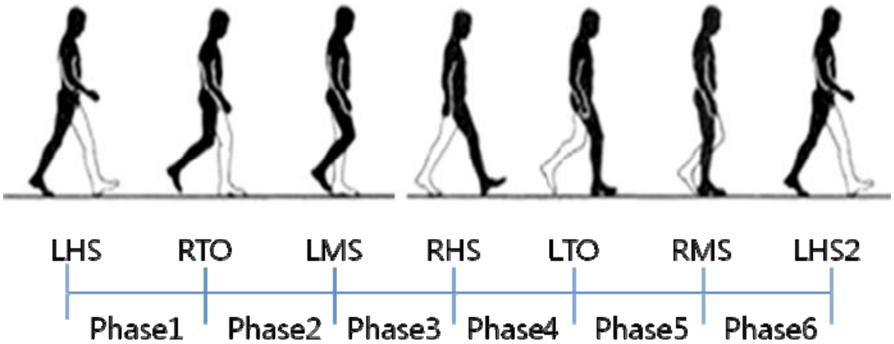


Figure 1: Events and phases during a gait.

RESULTS: Kinematic variables such as the left hip joint angle from the sagittal plane and trunk tilting angle from the frontal plane for each event were computed. Table 1 & 2 show mean and SD values of these parameters. Figure 2 also shows mean EMG values (%RVC) of eight muscles for each phase.

Table 1: Comparison of the left hip joint angles for each event (unit: degree).

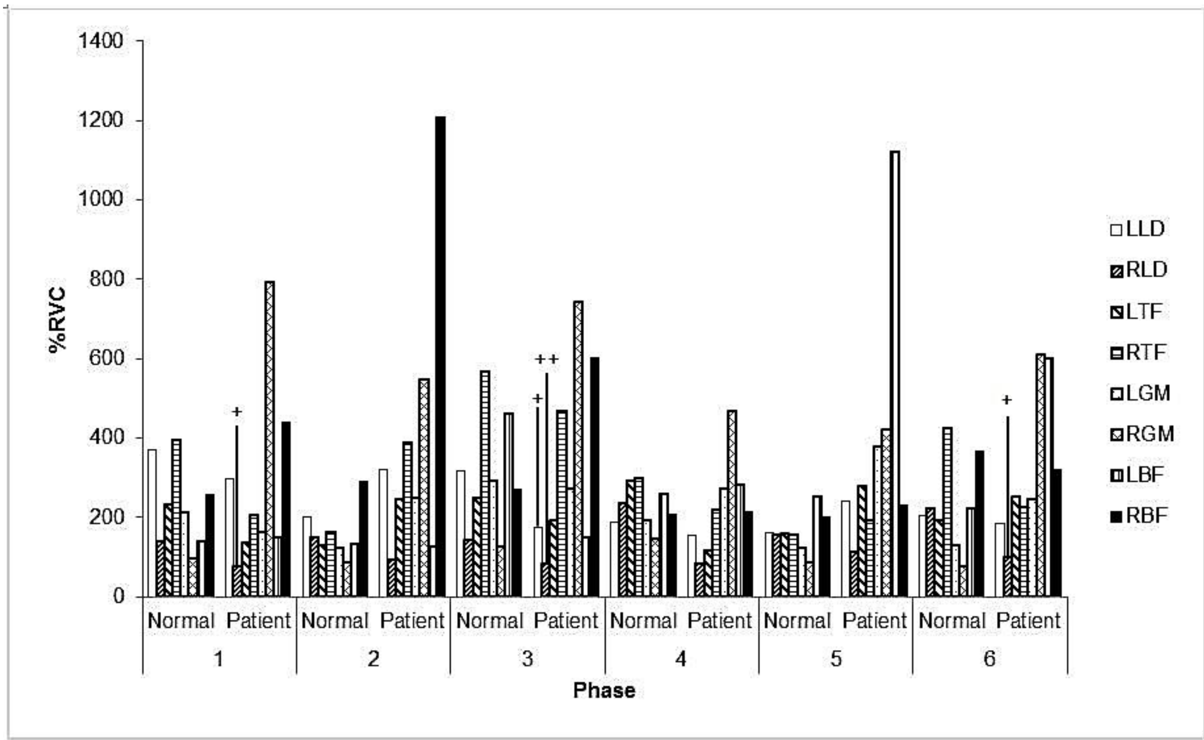
	LHS	RTO	LMS	RHS	LTO	RMS	LHS2
Control	75.61(4.33)	79.65(3.67)	98.46(5.19)	113.35(5.72)	102.35(6.33)	78.49(4.68)	75.90(3.34)
Patient	79.00(6.52)	81.27(7.72)	94.26(5.73)	107.00(6.08)	95.16(7.12)	72.94(2.95)	75.12(5.42)
t-value	0.989	0.429	1.262	1.772	1.752	2.598*	0.279

Note. * Significant difference between patient and control group

Table 2: Comparison of trunk angles for each event (unit: degree).

	LHS	RTO	LMS	RHS	LTO	RMS	LHS2
Normal	4.00(2.37)	3.49(0.79)	3.39(1.28)	2.85(1.70)	4.56(3.00)	3.25(2.52)	4.07(1.91)
Patient	5.29(4.66)	5.68(2.23)	5.07(2.16)	7.96(3.21)	9.02(2.61)	5.36(2.77)	6.04(3.02)
t-value	0.559	2.073	1.522	3.184*	2.636*	1.310	1.262

Note. * Significant difference between patient and control group



Note. + Significant difference between Normal and patient group
LLD; Left Latissimus Dorsi, RLD; Right Latissimus Dorsi, LTF; Left Thoracolumbar Fascia, RTF; Right Thoracolumbar Fascia, LGM; Left Gluteus Medius, RGM; Right Gluteus Medius, LBF; Left Biceps Femoris, RBF; Right Biceps Femoris.
Figure 2: Mean EMG values of selected muscles for each phase during a gait.

DISCUSSION: It was found that the idiopathic scoliosis patient group in adolescence showed a significantly smaller hip joint angle (p<.05) at RMS compared to the value of normal subject group. This indicates that patient group tends to elevate thigh segment more during walking. In addition, the trunk tilting angles of the scoliosis patient group were significantly larger at RHS and LTO compared to those of the control group (p<.05). Such results indicate that patients group fluctuated their trunk vertically more while walking than the control subjects. The EMG activity of the right latissimus dorsi of control group (139.17%) was higher than the value of patient group (75.84%) (p<.05) in phase 1. The EMG activities of the right and left latissimus dorsi of control group (142.40% and 316.93%) were also higher than those of the patient group (83.32% and 174.73%) (p<.01 and p<.05) in phase 3. The right latissimus dorsi of control group (221.88%) was significantly higher than that of the patient group (101.46%) (p<.05). It seems that the control subjects tend to use latissimus dorsi, muscle from the opposite side of the foot which landed on the ground, more than the patient group. In other words, since the patient group seemed to carry out gait motion with less use of latissimus dorsi, the idiopathic scoliosis patient put limits on the movement of their arms and upper body during walking. Besides, although significant differences were not founded due to the high standard deviations within the group, Figure 2 showed that patients produced very high activations of the right gluteus medius, and the right and left biceps femoris. For the normal gait pattern, gluteus medius was active muscle from the heel strike to the mid-stance phase (Kwon, Won, Oh, Lee, & Kim, 2006). Interestingly, this study revealed that patient group produced high EMG activity for the right gluteus medius throughout the all phases of the gait. They also generated very high EMG activities for the right biceps femoris from phase 2 to 3 and for the left biceps femoris in phase 5.

CONCLUSION: This study was conducted to investigate the differences in gait pattern between normal subjects and idiopathic scoliosis patients in adolescence by comparing their kinematic variables and muscle activity during walking. As a result of this study, it was found that idiopathic scoliosis patient group lifted the hip joint more than the normal group during walking. Trunk tilting angle of the patient group was also larger than the normal group. This meant that the scoliosis clearly induced abnormal posture during a gait. Small EMG activity of latissimus dorsi from the patient group suggested that an unusual gait pattern with limited upper trunk and arm movements were developed due to the scoliosis. It is expected that these results will be helpful for developing idiopathic scoliosis rehabilitation exercise and spinal correction apparatus in the future.

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