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A Study of Coupled Motion in Football, Baseball Players and General Students in Thoracic Spine

The objective of this study is to provide basic information on coupled motions in thoracic spine during lateral bending from a neutral position for football and baseball players as well as for general university students. In the experiment, a total of 30 subjects participated(football players: 10, baseball players: 10, general students: 10). All subjects were in their 20's. The subjects sat on a chair with lumbar support in a neutral position and bent to the right. As a result, for baseball players, coupled motions were observed in the opposite direction of the lateral bending in all parts of thoracic spine. For both football players and general students, coupled motions were observed in the same direction. These results confirmed that unilateral movements like baseball could affect coupled motions.

Key words: *Thoracic Spine; Lateral Bending; Coupled Motion*

Ok Kon Moon

Kunjang University College, Gunsan, Korea

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Address for correspondence
Ok Kon Moon, PT, Ph.D
Department of Physical Therapy, Kunjang University College, 536-3 Doam-ri, Seongsanmyeon, Gunsan-si, Jeollabuk-do, Korea
Tel : 82-63-450-8388
Email : ccon11@hanmail.net

INTRODUCTION

Lateral bending in the thoracic spine refers to rotation of bones around the Z-axis. In the human body, lateral bending is not a pure motion since it is coupled with a spine rotation around the Y-axis(1). Such unintended motion that follows the main motion which could move in the unexpected direction is called coupled motion(1-2). Gibbons et al.(2) stated that accurately identifying the direction of coupled motion is the basics of manual therapy when treating dysfunction of spine, since the type of exercise, either the mobilization or manipulation, is selected based on this direction.

Punjabi et al.(3) claimed that during lateral bending in the neutral position, a coupled motion is observed in all segments of thoracic spine in the opposite direction of the bending. Also, Kaltenborn(4) said that when bending laterally between thoracic spine 4 to 12(T4 to T12), the coupled motion occurs in the same direction of the bending, however during extension, the coupled motion occurs in the opposite direction of the bending as in the case of bending in the neutral position. On the other hand, Oxland et al.(5) claimed the coupled motion does not occur when manually bending T11 to T12 and T12 to L1 laterally, and Willems et al.(6) stated that the coupled motion varies for each spinal segment. In the past, it was said that coupled motions in thoracic spine have a consistent pattern(3, 4); however recently various studies have been proving that a different coupled motion is observed in each individual(5, 6).

Athletes like football and baseball players places pressure on a specific muscle and bone for a long period. This causes their posture to change to fit the sports they play, which is a different posture than the posture of an ordinary person(7). In their biomechanics study on instep football kick, Choi et al.(8) claimed that an impact occurs when the upper body rotates counterclockwise and the lower body's balance moves from the left to the right due to downswing. Kim et al.(9) stated that the 3D movements and twisting in football place pressure on the spine and can affect the movements of the spine, and more movements are observed in the lower spine than in the upper spine.

Han et al.(10) said when batting in baseball, a strong rotating motion from the lower body leads the upper body to rotate to hit the ball. Batting movement is the most well-known lateral rotary motion which can easily lead to muscle imbalance or spinal injury due to repetitive one-directional motions. It can also affect the movements of spine.

Spinal movements are three dimensional movements; therefore, to measure the coupled motion in the spine, each motion of segment needs to be measured in 3D to effectively show the actual spinal movements(11). Until now, study on coupled motion in the spine using 3D motion analysis tools were conducted with patients with chronic back pain(12), spinal instability patients(13), young adults(6), middle-aged women with no spinal problems(14), and individuals with no neck problems(15). However, there are not enough studies on the coupled motion of athletes in Korea. Sports that include a lot of body twisting and leaning like football and baseball are very likely to affect coupled motions in the spine. Thus, this study aims to provide basic information on coupled motions in thoracic spine during lateral bending from a neutral position for football and baseball players.

METHODS

Subjects

The subjects of this study include 10 football players, 10 baseball players, and 10 general students in K university located in Gunsan. The average years of playing the sports for the football and baseball players was 8 years. The football players only included strikers and defenders – no goalkeeper. The baseball players only included batters. The general students were individuals who did not participate in specific sports in the past three months. All participants were right-handed, and their age, height, and weight are summarized in Table 1. To test the homogeneity of variance, Levene's test was conducted. There was a statistically significant difference in age between groups(Levene F=7.172, P=.003), however no statistically significant difference was noticed for height(Levene F=.153, P=.859) and weight(Levene F=1.675, P=.206). Thus, it can be said that the difference in physical characteristics has been secured between the groups. Any participants with the history of lumbar or thoracic spinal injury or pain, have daily activity limitations due to spinal problems, have a long-term respiratory disorder, have received a spinal surgery, or have a clear spinal deformity were excluded from the experiment. Before the experiment, all subjects were given a thorough explanation on the purpose and procedure of the experiment and signed an agreement to participate.

Table 1. Subjects profile (M±SD)

Group	Football	Baseball	General
Age(years)	20.1±0.3	20.4±0.5	23.0±2.9
Weight(kg)	73.6±4.8	79.2±8.3	78.5±8.3
Height(cm)	176.7±5.4	181.9±5.1	177.1±6.1

Experimental Procedure

To analyze the coupled motion in the thoracic spine, a 3D motion analysis system(LUKOtronic, Lutz-Kovacs-Electronics, Austria) was used. A special chair was produced with the width of 50cm, length of 77cm, and height of 46cm. The lumbar support was 24cm-long. The length of chair was adjusted to fit the length of thigh of each subject.

The 3D motion analysis system was installed 2.8m away behind the subject to shoot the coupled motion in the spine . Considering the optical errors, the lens' optical axis was maintained parallel to the ground, 1.1 m above the ground.

Reflective Marker Attachment

All subjects were topless. Before attaching the reflective markers on the skin, the subjects shaved and used alcohol to sterilize to help reflective markers stick to skin better. To minimize the movement of reflective markers due to motions, they were attached on spinous process(1 each) and transverse process(2 each) of T1, T4, T8, and T12 while the subject is bending his thoracic spine 30°. The spinous process of T1 is located one level below the spinous process of C7, which is the part that protrudes the most when a person lowers his head. The marker for T4 was attached 3 spinous process below T1, and the marker for T8 was attached 4 spinous process below T4. The spot for T12 were found by finding 4 spinous process below T8, and the location was reconfirmed by remeasuring from the center of the line(2nd sacrum) that connects the right and left posterior superior iliac spine(PSIS). The marker for the transverse process of T1 is attached next to the spinous process of C7, the marker for the transverse process of T4, next to the spinous process of T3, the marker for transverse process of T8, next to the spinous process of T6 and T7, and the transverse process of T12, next to the spinous process of T11. In order to propose a reference value for the rotation that occurs

from the coupled motion during lateral bending, two markers were attached right and left of the upper center behind the lumbar support(2cm away from the center).

Posture and Experimental Procedure

The neutral position of the thoracic spine is defined as the posture where the person comfortably sits upright with his pelvis and back leaning on the lumbar support. To analyze the coupled motion in the thoracic spine, the subjects were asked to sit upright on the wooden chair with their knee joints bent 90° and with their two feet together parallel the ground. To observe only the motions in the thoracic spine during lateral bending, the lumbar support, pelvis belt, and thigh belt was used to eliminate any movements of lumbar and pelvis. To eliminate any upper body movements during the thoracic spine examination, the right arm was place on left shoulder and the left arm on the right shoulder comfortably. The jaw was pulled to the chest so there would be no neck movement during lateral bending. To allow the upper body to return to the starting position after lateral bending, a plate was placed 60cm in front of the subject so that the subject could check his position. The subjects started from the neutral position and bent to the right for three seconds, trying to bend as much as possible. The term between each lateral bending was 1 minutes, and a total of 3 sets were practiced. The subjects were instructed to hold the last posture for 3 seconds.

Analytical Method

For the analysis of the coupled motion in the thoracic spine, the 3D motion analysis system was utilized. The coordinates of space included Y-axis, the vertical axis, and X-axis for ventral and dorsal, and Z-axis for left and right. The plane created with Z-axis and X-axis, centering around the upper body of the subjects, was called the horizontal plane, and the one created with Y and Z-axis was called the frontal plane. The plane formed with Y and X-axis was named the sagittal plane. Each data was collected with 60Hz sampling rate. To have the camera of 3D motion analysis system recognize the markers, it was calibrated. The data was filtered using the 4D Butterworth low-pass filter with the cutoff frequency of 6Hz. Collected clips and numerical data of markers were processed using MS Excel 2007.

Data Analysis

The measured data in this study was analyzed with SPSS 15.0 ver. for Windows. To compare the coupled motion in the spine for football players, baseball players, and general students, the one-way ANOVA was conducted. When there was a statistically significant difference between groups, a post-hoc test, Bonferroni method was used to analyze with the significance level of .05.

RESULTS

Coupled Motion in Lateral Bending

During lateral bending, the football players and general students had a coupled motion in the same direction in T1-T4, T4-T8, and T8-T12; the baseball players had a coupled motion in the opposite direction. The football players and general students had a greater(statistically significant) angle of coupled motion in T4-T8 compared to baseball players($p<.05$) as shown in Table 2.

Table 2. Coupled motion in lateral bending

(unit : °)

Level	Football	Baseball	General	F	P
T1-T4	-0.0±1.3	-0.3±1.6	1.1±2.7	.622	.545
T4-T8	1.9±1.4[a]	-1.7±1.7[b]	1.8±1.9	4.740	.017*
T8-T12	0.8±2.7	-0.7±3.7	0.7±3.8	2.821	0.75

*p<.05
a: significant difference between Football and Baseball player
b: significant difference between General and Baseball player
(+) values: same direction to sidebending for coupled rotation
(-) values: opposition direction to sidebending for coupled rotation

DISCUSSION

The objective of this study is to provide information on the direction of coupled motion in the spine during lateral bending for football players, baseball players, and general students. All main motions are coupled with another motion in another plane(2). In particular, extension, flexion, and rotation follows the lateral bending, and this motions are called coupled motion(1). A study that used cadaver claimed that the coupled motion is shown most clearly between lateral bending and rotation, and between rotation and lateral bending(16). For easier understanding on coupled motion, lateral bending, rotation, and extension-flexion angles need to be explained with simple numbers(17). This study utilized the 3D motion analysis system to measure the angle of coupled motion during lateral bending.

White et al.(11) claimed that when bending laterally from the neutral position, the coupled motion is in the same direction with the lateral bending in T1-T4, in the opposite direction in T4-T8, and either in the same or opposite direction in T8-T12. Veldhuizen et al.(19) explained that this displacement is observed because the centrum of the spine is in the sagittal plane. They said that when the centrum leans towards the front, the coupled motion occurs in the same direction as the lateral bending, and when the centrum leans towards the back, the coupled motion occurs in the opposite direction. Thus, they insisted that the debates in literature exist because of the various forms that the sagittal plane takes. Willem et al.(6) was the only group that used the 3D Fastrak System to observe coupled motion in the spine during lateral bending started from the neutral position. The experiment included 30 subjects - healthy male and female aged between 18 and 24- with optical reflective markers on their spinous processes. They said the direction of coupled motion varies in each area of spine, showing that T1-T4 matched the direction of lateral bending by 47%, T4-T8 by 83%, and T8-T12 by 68%. They stated that T4-T8 matches the direction the best.

In this study, the coupled motion of the baseball players was in the opposite direction of lateral bending whereas the coupled motion of the football players and general students was in the same direction. Lee et al.(7) said that repetitive one-directional movement can affect the movements of spine. According to this finding, it is assumed that the baseball players have a coupled motion in the opposite direction of lateral bending due to the characteristics of batting movements while the football players have a coupled motion in the same direction. For the baseball players, a coupled motion in the opposite direction was observed in T4-T8 and T8-T12, which agrees with the experimental result obtained by Panjabi et al.(3). However, the result of this study disagrees with the findings of Veldhuizen et al.(18), as it showed that the effect of anatomic arrangement of spine on the coupled motion is insignificant.

The direction of coupled motion shows a consistent pattern in a specific posture depending on the sports the athlete plays, which means that the pattern would not be regular in different postures. It is possible that the inconsistent pattern in the direction of coupled motion would lead to inconsistent examination and treatment effect. Therefore, when employing coupled motion in the clinical care for football or baseball players, one should be careful to conclude the variance in coupled motion a pathological pattern. The coupled motion pattern may be different for each individual and may be different by sports. For this reason, applying a uniform therapeutic method based on coupled motion for all patients would have limitations. This study only employed a limited number of participants(10 for each group) and only observed the coupled motion during lateral bending to the right. Therefore the result cannot be generalized. I believe more studies will be required to identify the factors that actually affect the coupled motion during lateral bending.

CONCLUSION

After analyzing, with the 3D motion analysis tool, the result from the experiment conducted with 10 football players, 10 baseball players, and 10 general students on the coupled motion in the thoracic spine during lateral bending from the neutral position, it was found that the baseball players have coupled motion in the opposite direction of the lateral bending, while the other two groups moved in the same direction.

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