

## Comparison of Muscle Activity of the Erector Spinae according to Thoracic Spine Extension Mobility

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**Background** During trunk extension, the thoracic extensor is decreased and the lumbar extensor is excessively activated, which is a factor inducing low back pain.

**Purpose** The purpose of this study is to compare the muscle activity of the erector spinae of the thoracis and the lumborum during trunk extension according to the thoracic spine extension mobility.

**Study design** Cross-sectional study.

**Methods** 94 participants measured thoracic spine extension mobility and assigned low mobility group (n=31) and high mobility group (n=31) according to the mean and standard deviation. The muscle activity of the erector spinae was measured when participants maintained their trunk extension at the prone position. An independent *t*-test was used to compare the muscle activity between the low and high mobility groups.

**Results** The muscle activity of longissimus thoracis, the ratio of longissimus thoracis:iliocostalis lumborum pars lumborum, and iliocostalis lumborum pars thoracis:iliocostalis lumborum pars lumborum was significantly different between the high and low mobility group ( $p<0.05$ ).

**Conclusions** The muscle activity of longissimus thoracis and ratio between the thoracis and the lumborum of the erector spinae are reduced in the low mobility group than the high mobility group during trunk extension.

**Key words** Erector spinae; Muscle activity; Thoracic spine extension mobility; Trunk extension.

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### INTRODUCTION

Mechanical pain disorders of the thoracic spine are commonly associated with impairment of thoracic spine mobility.<sup>1-3</sup> Impairment of thoracic spine mobility is frequently reported in axial rotation and extension.<sup>4</sup> Thoracic spine extension mobility (TE) is required in the end range of shoulder flexion,<sup>5</sup> and is essential for ideal pattern of trunk extension.

Prone trunk extension is performed to check the ideal trunk extension pattern.<sup>6</sup> Park et al. reported that those with a slouched posture had smaller thoracic spine extension and greater lumbar extension during the prone trunk extension

compared to those without slouched posture.<sup>7</sup> Also, the muscle activity ratio between the thoracis and lumborum of erector spinae was lower in those with a slouched posture.<sup>7</sup> During prone trunk extension, the thoracic extensor is decreased and the lumbar extensor is excessively activated, which is a factor inducing low back pain.<sup>8-10</sup> Therefore, muscle activity of thoracic erector spinae was emphasized to manage and prevent low back pain.<sup>11</sup>

During the thoracic extension, the thoracic erector spinae such as longissimus thoracis (LT), and iliocostalis lumborum pars thoracis (ICT) are activated.<sup>6,7</sup> However, since the erector spinae muscle of lumborum such as iliocostalis pars lumborum (ICL) can be used as compensation during trunk

extension, it is important to confirm the ratio between the thoracis and the lumborum of the erector spinae such as LT:ICL and ICT:ICL.<sup>6,7,12</sup> Therefore, the current study compares the muscle activity ratio between the thoracis and the lumborum of the erector spinae according to TE during prone trunk extension. It was hypothesized that the individuals with high TE will have greater muscle activity of thoracis and ratio between the thoracis and the lumborum of the erector spinae compared with low TE.

## METHOD

### Participants

Ninety-four healthy individuals who thought they had hyperkyphosis were recruited through Internet advertisements in Table 1. Individuals with the following characteristics were excluded: scoliosis and a history of spinal column fracture, spinal tumors and related malignancies, congenital spinal anomalies, cancer, or rheumatoid arthritis.<sup>13</sup> Participants measured thoracic spine extension mobility (TE) using a spinal mouse (Idiag AG, Fehraltorf, Switzerland) and assigned groups according to mean and standard deviation (mean=24.76, standard deviation=9.69). Participants with TE greater than 1/2 standard deviation from the mean were assigned to the high mobility group (>29.6, n=31), and those with TE less than 1/2 standard deviation from the mean were assigned to the low mobility group (<19.9, n=31). Thirty-two participants who did not meet the group assignment criteria were excluded from the study. The study was approved by the Institutional Review Board of Yonsei University Wonju (1041849-202101-BM-009-01).

### Thoracic spine extension mobility

The angle of TE was defined as the difference between

the angle of thoracic kyphosis in standing and the end range angle during thoracic extension.<sup>1</sup> The angle of thoracic kyphosis in standing and the end range angle during thoracic extension was measured using a Spinal Mouse (Idiag AG, Fehraltorf, Switzerland). To measure the angle of thoracic kyphosis, each participant was instructed to stand in a comfortable (habitual) position facing the front with the crossed-arm (Figure 1).<sup>14</sup> Then, the participant wrapped both hands behind the head with the upper arms against the ears for the end range angle during thoracic extension.<sup>14</sup> The participants were instructed to “point the

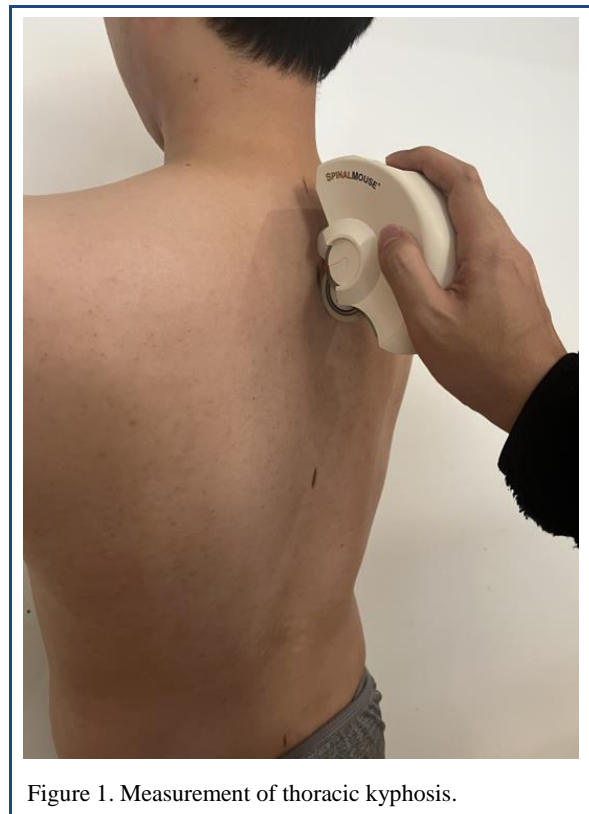


Figure 1. Measurement of thoracic kyphosis.

Table 1. Demographic data

	Low mobility group	High mobility group	<i>t</i>	<i>p</i>
Age (yrs)	36.65±6.40	33.81±7.05	1.660	0.102
Sex (male/female)	25/6	18/13	-	-
Height (cm)	171.56±7.91	169.06±6.89	1.327	0.189
Weight (kg)	74.68±15.26	73.49±15.59	0.302	0.763
Body mass index ( kg /m <sup>2</sup> )	25.15±3.83	25.55±4.21	-0.398	0.692
Thoracic kyphosis (°)	41.03±8.45	43.73±9.42	-1.189	0.239
TE (°)	13.87±4.81	35.46±4.59	-18.082	0.000*

TE: thoracic spine extension mobility, Data are expressed as mean±standard deviation, \* *p*<0.05.

elbows toward the ceiling and arch backward.” We measured the angle of thoracic kyphosis and end range during thoracic extension twice. For global spinal angles, the device is a reliable and valid device.<sup>15-17</sup>

### Instrumentation

#### 1) Spinal mouse

The angle of thoracic kyphosis and end range during thoracic extension was measured using a Spinal Mouse system (Idiag, Fehraltorf, Switzerland).<sup>18</sup> The Spinal Mouse has accelerometers that record change of inclination and intersegmental distance of spinous processes. The device contains two rolling wheels follow the spinous processes of the spine, and the data are transferred from the device to a computer (sampling frequency of approximately 150 Hz).<sup>19</sup> These data are used to calculate the relative angles between the vertebrae and total angle of sagittal plane using Spinal Mouse software. For global spinal angles, the device is a reliable and valid device.<sup>15-17</sup>

#### 2) Electromyography

The muscle activity of the LT, ICL, and ICT was measured using the Noraxon Ultium ESP System (Noraxon USA, Inc., Scottsdale, AZ) according to Criswell.<sup>20</sup> Skin impedance was reduced by shaving excess body hair, if necessary, gently abrading the skin with fine grade sandpaper, and wiping the skin with alcohol swabs. Signals were collected using MyoMuscle™ MR3 3.14.52 (Noraxon Inc.). The raw electromyography signals were band-pass filtered (20–450 Hz), and the root mean square values were calculated using a 50-ms window. Data were recorded at a sampling rate of 2,048 Hz. The muscle activity was measured when participants maintained their thoracic extension at the prone position (Figure 2).<sup>14</sup> And the muscle activity was expressed in % maximum voluntary isometric contraction.

### Statistical analysis

Statistical analyses were conducted with SPSS ver. 20.0 (SPSS Inc., Chicago, IL, USA). The Kolmogorov-Smirnov test was used to confirm that the data were normally distributed. An independent *t*-test was used to compare the muscle activity of LT, ICT, ICL, ratio of LT:ICL, and ICT:ICL between the low and high mobility groups. A value of  $p < 0.05$  was taken to indicate statistical significance.

## RESULT

All variables showed a normal distribution in Kolmogorov-

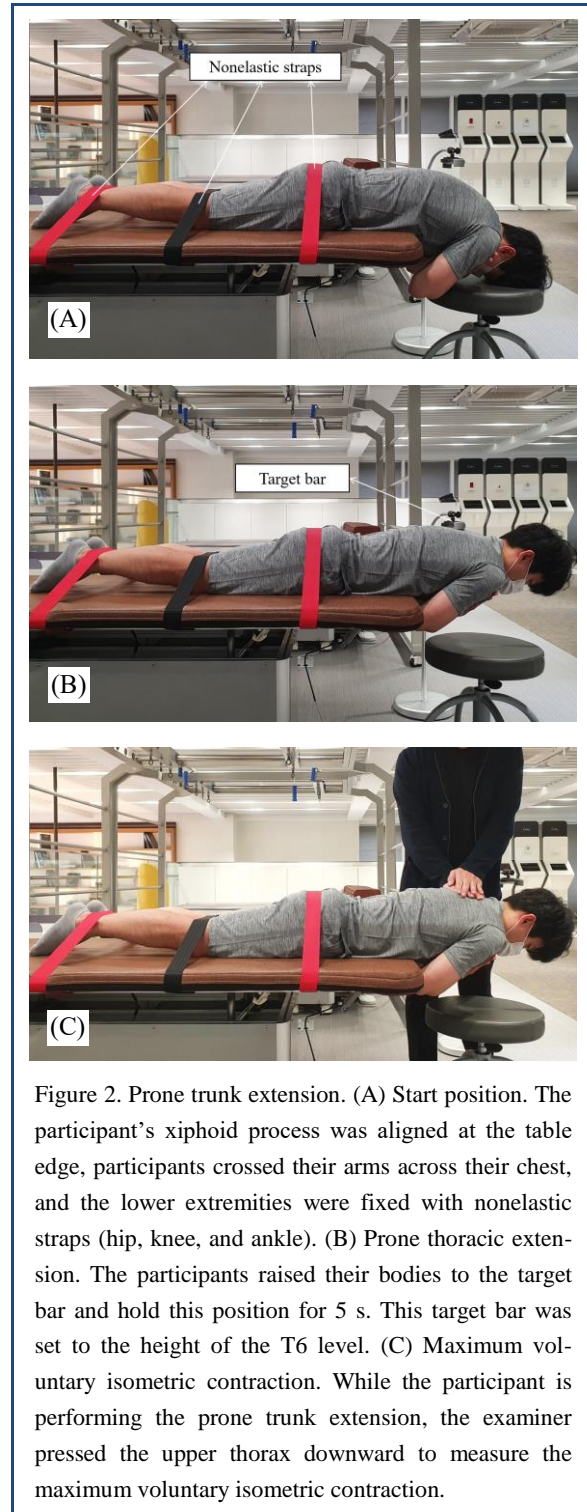


Figure 2. Prone trunk extension. (A) Start position. The participant's xiphoid process was aligned at the table edge, participants crossed their arms across their chest, and the lower extremities were fixed with nonelastic straps (hip, knee, and ankle). (B) Prone thoracic extension. The participants raised their bodies to the target bar and hold this position for 5 s. This target bar was set to the height of the T6 level. (C) Maximum voluntary isometric contraction. While the participant is performing the prone trunk extension, the examiner pressed the upper thorax downward to measure the maximum voluntary isometric contraction.

Smirnov test ( $p > 0.05$ ). The result for the independent *t*-test between the low and high mobility groups is shown in Table 2. The muscle activity of LT, the ratio of LT:ICL, and ICT:ICL significantly increased in the high mobility group ( $p < 0.05$ ).

Table 2. Comparison of the muscle activity between the low and high mobility groups

	Low mobility group	High mobility group	<i>t</i>	<i>p</i>
LT	23.68±8.74	35.20±19.08	-3.057	0.003*
ICT	34.63±12.21	38.54±18.03	-1.000	0.322
ICL	49.40±13.72	48.23±17.81	0.290	0.773
Ratio of LT:ICL	0.51±0.18	0.73±0.24	-4.073	0.000*
Ratio of ICT:ICL	0.71±0.16	0.80±0.17	-2.236	0.029*

LT, longissimus thoracis; ICT, iliocostalis lumborum pars thoracis; ICL, iliocostalis lumborum pars lumborum.

Data are expressed as mean±standard deviation, \*  $p < 0.05$ .

## DISCUSSION

In a previous study, the difference in muscle activity during prone trunk extension was compared by dividing groups according to alignment such as slouched posture.<sup>7</sup> However, since the muscle activity is accompanied by mobility, not only alignment but also movement should be considered. Therefore, in this study, the high mobility group and the low mobility group were divided and compared according to TE, and there was a significant difference between the groups in ratio of LT:ICL, ICT:ICL, and muscle activity of LT.

The ratio of LT:ICL and ICT:ICL means the balance of the erector spinae muscle, and the closer the value is to 1, the better the balance of erector spinae between thoracis and lumborum. Park et al. reported that the ratios of individuals without slouched posture were 0.82 and 0.88 (LT:ICL, ICT:ICL sequentially), which is similar to the ratio of the high mobility group in this study (0.73 and 0.80).<sup>7</sup> Therefore, as a result of this study, it can be confirmed that the balance of the erector spinae between thoracis and lumborum is reduced in the low mobility group, which can be a factor of low back pain.<sup>8-10</sup>

Jung et al. reported that muscle activity of LT decreased after improving thoracic extension by applying thoracic mobilization to individuals with hyperkyphosis.<sup>14</sup> However, in this study, muscle activity of LT was significantly larger in the high mobility group than the low mobility group. This suggests that not only musculoskeletal factors but motor control factors should be considered in order to improve kinetics including muscle activity as well as kinematics.

Our study has some limitations. First, we enrolled relatively young participants. Thus, our findings cannot be generalized, to participants with old-age. Second, we did not investigate lumbar kinematics during the experiment; future studies should observe lumbar kinematics to confirm the compensatory movement of the lumbar spine during

prone trunk extension.

## CONCLUSIONS

We found that the muscle activity of LT, and the ratio between the thoracis and the lumborum of the erector spinae is reduced in the low mobility group than the high mobility group during the prone trunk extension. Therefore, we suggest that it should be considered to activate the erector spinae of thoracis and to maintain the balance between the thoracis and lumborum of the erector spinae when treating and managing patients with low thoracic extension mobility.

### Key Points

**Question** Is there any difference in muscle activity of the erector spinae in individuals with low thoracic spine extension mobility compared to individuals with high thoracic spine extension mobility?

**Findings** The muscle activity of the erector spinae of thoracis, and the ratio between the thoracis and the lumborum of the erector spinae is reduced in individuals with low thoracic extension mobility than individuals with high thoracic extension mobility.

**Meaning** When treating and managing patients with low thoracic extension mobility, it should be considered to activate the erector spinae of thoracis and to maintain the balance between the thoracis and lumborum of the erector spinae.

### Article information

Conflict of Interest Disclosures: None.

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Ethic Approval: The study was approved by the Institutional Review Board of Yonsei University Wonju (1041849-202101-BM-009-01).

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