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Original articles

Correlations of Symmetry of the Trunk Muscle Thickness by Gender with the Spinal Alignment in Healthy Adults

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Purpose: Most studies have reported that the abdominal muscle thickness differs according to gender but none of these studies reported a gender difference in the thickness of the multifidus and erector spine. The spinal alignment is affected by the left and right balance in the trunk muscle. The aim of this study was to identify the trunk muscle symmetry according to gender and the correlations of the trunk muscle thickness with spinal alignment.

Methods: Forty three subjects(27 males and 16 females) were enrolled in this study. The trunk muscle thickness was measured by ultrasonography. The trunk muscle, which consisted of the rectus abdominis (RA), external oblique abdominis (EOA), internal oblique abdominis (IOA), transverse abdominis (TrA), erector spine (ES), and multifidus (MF), was measured. The spinal alignment was measured by Formetric-Ⅲ 3D analysis. The dependent variables of the spinal alignment were the trunk imbalance, trunk inclination, lateral deviation, and surface rotation.

Results: The muscle thickness of the EOA muscle increased more significantly in the right side than the left side (p<0.05). Each left and right difference in the muscle thickness between the male and female group showed a significant difference (p<0.05) except for the TrA thickness. Significant positive correlations were observed between the ES and lateral deviation and between the TrA with trunk imbalance.

Conclusion: These results suggest that asymptomatic men have a greater trunk muscle thickness than women but there was no difference between the left and right in healthy adults. The trunk muscle thickness of ES, TrA is related by the spinal alignment.

Key Words: Spine, Ultrasonography, Symmetry

Ⅰ. Introduction

The trunk muscles, which include the external oblique abdominis (EOA), internal oblique abdominis (IOA), transverse abdominis (TrA), and multifidus (MF), play essential roles in maintaining the stability of the trunk. The ability of these muscles to provide spinal stability are related to their ability to produce spinal movement.[1] The stability of the lumbar spine is related to low back pain.[2] In particular, the inner deepest trunk muscle, which is known as the core stability muscle is associated with the lumbar stability.[3] In addition, a co-contraction of the trunk flexors and extensors gives rise to an increase in the stability of the spine.[1,4] The structure that controls the lumbar stability contains bone, cartilage, ligaments, nerves, and muscle. These anatomical components provide the spine type and function. The muscles involved in this process are typically grouped into two different types. These types are divided into primary or secondary muscles. The muscles provide the functional mechanism for the movement and stability of the spine.[5]

The primary muscles consist of two major groups of lumbar extensors (MF, erector spine (ES)). The secondary muscles consist of four major groups of lumbar flexors(rectus abdominis (RA), EOA, IOA, TrA). Although the abdominal

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muscles are not attached directly to the lumbar spine, these muscles play important roles in adjusting the lumbar spine motion.[6]

Because the trunk muscles support the spine, any deformation of the spine would be associated with some asymmetry of the trunk muscles. Rankin et al.[7] examined the abdominal muscle size and symmetry at rest in 123 healthy subjects comprised of 55 men (aged 21–72 years) and 68 women (aged 20–64 years). They reported a difference in the trunk muscle thickness according to gender. The results showed that men had greater muscle thickness (RA>IO>EO>TrA) at rest than women. Springer et al.[8] found that men have a greater TrA thickness than women at rest. Nevertheless, neither study found whether the trunk muscle thickness including the MF and ES showed gender differences.

The alignment of trunk will have an effect on the asymmetric between left and right in trunk. Primarily, the posture was attributed to the left and right imbalance in the trunk muscle. Koppenhaveret al.[9] reported that an improvement in the disability and changes in the abdominal and MF thickness patients with low back pain can be induced by spinal manipulative therapy. The clinical improvement after manipulation was associated with the MF muscle thickness. The aim of this study was to identify the trunk muscle symmetry according to gender as well as the correlations of the trunk muscle thickness with the spinal alignment.

II. Methods

1. Subjects

This study was conducted at S university located in Jeonbuk. Forty three subjects(27 males, 16 females) were enrolled. All participants signed informed consent and had the right to withdraw from the study at any time. All participants were healthy in their twenties. The inclusion criteria were as follows: (1) subjects without facet joint inflammation and spondylolisthesis, (2) no orthopedic problems in the pelvis and lower extremities, (3) none had exercised regularly and (4) there was no lower back pain.

2. Experimental methods

1) Measurement

(1) Muscle thickness using ultrasonography

The thickness ofthe trunk muscles in this study was measured by ultrasonography using MyLabOne(Esoate, Italy) (Figure 1). The spectral range of this equipment was 6~9 ㎒ and the range of gain was 20~80%. Four abdominal muscles were examined: RA, EOA, IOA, and TrA. Two back muscles were examined: ES and MF. Using a 13~6 ㎒ linear transducer (SL3323), the thicknesses of RA, EOA, IOA and TrA were measured in the hook-lying position. Using a 10~6 ㎒ convex transducer (SC3123), the thickness of the ES and MF was measured in the prone position. The thickness of all muscleswas measured in both sides. The thickness of the RA was measured 4㎝ lateral away from the umbilicus.[10] The thickness of the EOA, IOA, and TrA were measured 2.5㎝ anterior away from the axillary line, toward the height of the umbilicus. The ES measurement site was measured 3㎝ lateral away on the spinous process in L3. The MF was measured 2㎝ lateral away on the L4/L5 zygapophyseal joint.[11] It was moved laterally and angled slightly medially until the L4/5 zygapophyseal joint could be identified.[12] After sonographic measurements, all the data was analyzed in the digital image program (Media Cybernetics, USA).

(2) Spinal alignment

To assess the subject's spinal alignment, each subject underwent a Formetric-Ⅲ(Diers, Germany) 3D-analysis test, which measured their back and spine conditions. The Formetric-Ⅲ instrument system is a reliable method for three-dimensional(3D) back shape analysis of the spinal alignment using a halogen lamp without radiation exposure.[13] This equipment shows high accuracy and reliability compared to X-rays.[14,15] The patients were in the standing position in a darkened room. Their body was illuminated from behind with parallel light lines, and a picture was taken from a certain angle from above to below. The equipment total distancewas 3~5 m. All subjects were instructed to adopt a standing relaxed posture and the neck was flexed at 10~15° to check the presentation of C7. In addition, the rater asked each subject

Table 1. Comparison of the symmetry and thickness in trunk muscles according to gender. (units: ㎜)

	Male		p	female			between groups	
	left	right		left	right	p	left (p)	right (p)
RA	[a]11.65±2.09	11.87±2.13	0.317	8.11±2.13	8.84±1.05	0.204	0.00*	0.00*
EOA	5.48±1.43	5.86 ± 1.59	0.240	3.52±0.81	4.21±0.94	0.002*	0.00*	0.00*
IOA	7.80±2.52	8.03±1.68	0.948	5.73±1.06	5.89±0.80	0.596	0.00*	0.00*
TrA	3.70±1.36	3.57±0.99	0.630	3.65±0.96	3.26±0.78	0.133	0.888	0.298
ES	31.72±5.55	32.50±4.98	0.528	27.61±5.07	29.41±4.36	0.133	0.020*	0.046*
MF	26.72±3.84	26.46±4.13	0.675	23.81±4.31	24.38±2.39	0.614	0.043*	0.027*

*p<0.05
[a]Mean ± standard deviation, RA: Rectus abdominis, EOA: External oblique abdominis,IOA: Internal oblique abdominis
TrA: Transverse abdominis, ES: Erector spine, MF: Multifidus

Table 2. Correlation analysis of spinal alignment and the thickness difference between the left and right muscles

		RA(r)	EOA(r)	IOA(r)	TrA(r)	ES(r)	MF(r)
Trunk inclination	[a]1.28±2.10	0.08	0.13	0.03	0.20	0.17	0.07
Lateral deviation	4.51±2.25	-0.17	0.03	0.17	0.25	0.40*	-0.02
Trunk imbalance	1.10 ± 11.37	-0.18	0.22	0.27	0.34*	-0.01	-0.04
Surface rotation	3.56±1.72	0.12	0.03	-0.04	0.13	0.28	0.05

[a]Mean ± standard deviation
*p<0.05
RA: Rectus abdominis, EOA: External oblique abdominis, IOA: Internal oblique abdominis, TrA: Transverse abdominis, ES: Erector spine, MF: Multifidus

III. Results

1. General characteristics of subjects

The subjects were comprised of 27 males(63%) and 15 females(37%). The mean age of the participants was 24 years. The mean height of the participants was 168.2㎝. The mean weight of the participants was 61.9kg.

2. Comparison of the symmetry and thickness in the trunk muscles according to gender

The average muscle thickness of the female group in the left and right EO muscle was 3.52±0.81㎜ and 4.21±0.94 ㎜, respectively. Therefore, the muscle thickness of the right side in the EO muscle was significantly higher than the left side ($p<0.05$). Each left and right difference in the muscle thickness between the male and female group showed a significant difference ($p<0.05$) except for the TrA thickness (Table 1).

3. Correlation analysis of spinal alignment and the thickness difference between the left and right muscles

The ES with lateral deviation (Figure 2) and TrA with trunk imbalance (Figure 3) showed a significant positive correlation ($p<0.05$)(Table 2).

IV. Discussion

Previous studies have reported the symmetry of the abdominal muscles, such as TrA and IOA, but there has been little research on the left-right imbalance of the trunk muscle including MF and ES. The difference in muscle thickness according to gender is insufficient. The body posture is affected by trunk muscle imbalances. The aim of this study was to determine the difference in the trunk

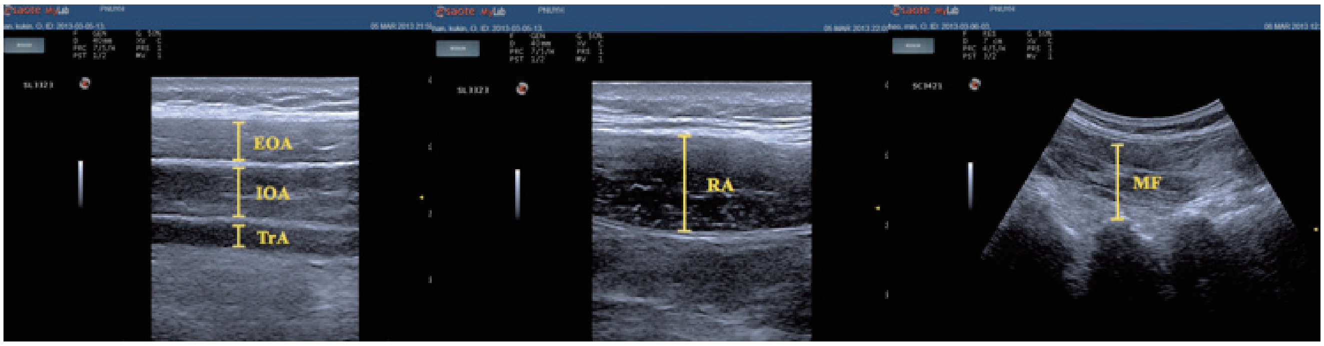

Figure 1. Picture of measuring the trunk muscle thickness using ultrasonography.
EOA: External oblique abdominis, IOA: Internal oblique abdominis, TrA: Transverse abdominis, RA: Rectus abdominis, MF: Multifidus

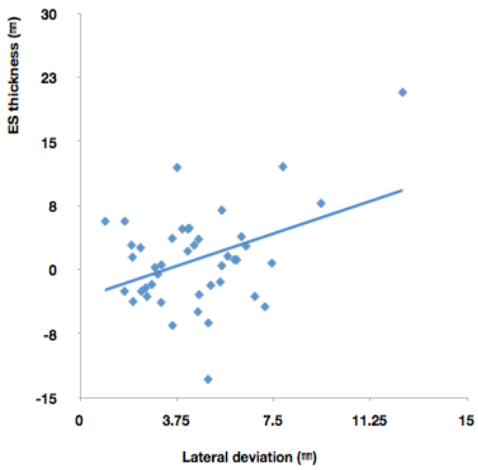

Figure 2. Correlation of ES thickness difference and lateral deviation
ES: Erector spine

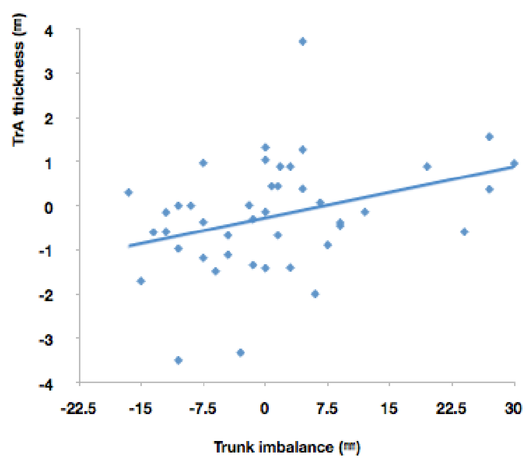

Figure 3. Correlation of TrA thickness difference between left and right and trunk imbalance
TrA: Transverse abdominis

muscle symmetry according to gender and the correlations of the trunk muscle thickness with the spinal alignment.

Ultrasonography was used to measure the trunk muscle thickness. Measurements of the trunk muscle thickness using ultrasonography have been proven to be reliable and non-invasive. Mayans et al.[16] claimed that ultrasonography is capable of measuring the size difference of the trunk muscles in adult men and women or children and seniors. The other advantages of ultrasonography are that it is a robust instrument and a more cost-effective method than MRI.

The muscle thickness of the EOA muscle in female group was higher in the right side than the left side. The other trunk muscles showed no significant difference between left and right. Stokes et al.[17] reported a normal reference value for the MF in 120 healthy adults, and Rankin et al.[7] published the normal reference ranges for the abdominal muscles of 130 health adults. This study showed that the thickness of the left and right in the EOA was 5.9㎝ and 5.8 ㎝, respectively. These findings showed that left and right thickness of the EOA was 3.5㎝ and 4.2㎝, respectively. The thickness of trunk muscle is dependent on the imaging region. Therefore, direct comparisons with a previous study that used different imaging regions are difficult. On the other hand, when measuring, the pressing pressure of the transducer appears to make a contribution because the EOA is located at the top of the abdominal muscle.

A comparison of the muscle thickness between the male and female group showed a significant difference except for TrA, i.e. gender differences were observed in the RA, EOA, IOA, ES, and MF muscle thickness. A gender difference was also found in this study because men have significantly larger muscle mass than women. In general, these findings are consistent with previous findings.[7,17] Rho et al.[18] also reported that men had a greater muscle resting thickness of the IOA than women.

Teyhenet al.[19] suggested that the thickness of the TrA muscle at rest was equivalent between males and females. The other study showed that females have a larger relative thickness (difference between contracted and rest) of the TrA than males.[8] These findings show that the TrA muscle did not show a significant difference between males and females. A possible explanation is that the TrA indicates a relatively greater proportion among the lateral abdominal wall in women than men.[8] That is, the TrA in the female group is as thick as the TrA in male. This might be an indicator of the differences in neuromuscular control between genders. Therefore, the gender should be considered when TrA strengthening is included in lumbar stabilization exercise.

Most studies have focused on the imbalance of trunk muscles in stroke patients and back pain patients, and we could find no studies which focused on correlation between muscle imbalance and spinal alignment. Therefore, the results of this study about healthy adults might be used as empirical data.

The changes in the musculoskeletal system would be disturbed by factors, such as the range of motion of the spine, trunk muscle strength.[20] Pearson correlation analysis was used to examine the correlations of the trunk muscle with spinal alignment. A significant positive correlation was observed between the trunk imbalance and TrA muscle. The difference in TrA thickness increased with increasing trunk imbalance. The meaning of the trunk imbalance indicated that the connected line between C7 and the connected midpoint of both PSIS showed a deviation from one central point. That is, trunk imbalance means that the trunk has been tilted to the left and right, and a value closer to 0 indicates the symmetry of the left and right.

The TrA muscle are important for stabilizing the trunk.[21] An intended action is more difficult to perform by people with musculoskeletal system disorders. People who complain of back pain show differences in the thickness of TrA on both sides.[22] On the other hand, Seo et al.[23] was reported that the changes in thickness of the muscles on the left and right sides showed no significant correlations with balance ability.

A significant positive correlation was observed between the lateral deviation and ES muscle. The difference in ES thickness increases with increasing lateral deviation. The meaning of the lateral deviation suggests that the connected line between C7 and connected midpoint of both PSIS presents the maximal distance from the midline. Generally, scoliosis is considered if the lateral deviation is larger than the normal reference value. To see a functional scoliosis diagnosisis widely used to apply using the forward bending test[24]. The test is performed in the standing position. If the functional scoliosis is present, that is meant difference between the left and right erector spine muscle. Reeves et al.[25] was reported that difference between left and right of lumbar erector spinae are closely related to pathological factors. Generally, symmetrical co-contraction between erector spinae increases the trunk stability.

This study had some limitations. This study was conducted in healthy adults without musculoskeletal problems (e.g. low back pain). This work was a pilot study to examine the trunk thickness with ultrasonography but the sample size was small. Therefore, it is difficult to generalize the data. Future studies will be needed to compare the relationship between healthy adults and neuromuscular disorder patients, as in a previous study.[26] Additional studies in arange of positions will be necessary to compare the symmetry of the trunk muscle according to gender.

These results suggest that asymptomatic men have a greater trunk muscle thickness than women. No difference was observed between the left and right sides in healthy adults. Gender should be considered when TrA strengthening is included in a lumbar stabilization exercise program. The trunk muscle thickness of ES, TrA is related to a trunk imbalance and lateral deviation.

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