J.Phys. Ther. Sci
23: 855-858, 2011

Differences in Abdominal Muscle Thicknesses between Chronic Low Back Pain Patients and Healthy Subjects

Megumi Ota, MS[1,2], Koji Kaneoka, MD[3]

[1] *Graduate School of Sport Sciences, Waseda University: 2–579–15, Mikashima, Tokorozawa-shi, Saitama-ken, 359-1192 Japan. TEL & FAX: +81 42-947-6958, E-mail: Meg.oht@akane.waseda.jp*
[2] *Tokyo Eisei Gakuen College*
[3] *Faculty of Sport Sciences, Waseda University*

Abstract. [Purpose] It has been reported that chronic low-back pain (CLBP) patients exhibit asymmetric atrophy of the lumbar multifidus muscle. However, studies focusing on the abdominal muscles have not yet been conducted. The purpose of this study was to determine abdominal muscle thickness and symmetry in CLBP patients and healthy subjects. [Subjects and Methods] Data were obtained from 50 healthy subjects (30.2 ± 6.1 years) and 50 CLBP patients (31.5 ± 8.7 years). The thicknesses of the rectus abdominis (RA), external oblique (EO), internal oblique (IO), and transversus abdominis (TrA) were measured by ultrasonography. We calculated the mean thicknesses of both sides. In addition, we calculated the asymmetry ratio as a percentage of the difference between the sides. The differences in muscle thickness between the CLBP patients and healthy subjects were analyzed using the t-test. [Results] We found that the TrA thickness was significantly smaller in CLBP patients (3.7 ± 0.8 mm) than in healthy subjects (4.2 ± 1.2 mm). Similarly, the TrA asymmetry ratio was significantly different between the healthy subjects (8.4 ± 7.5%) and CLBP patients (16.4 ± 12.1%). [Conclusion] The TrA muscle of CLBP patients was thinner and more asymmetric than that of healthy subjects.

Key words: Low back pain, Muscle thickness, Transversus abdominis

(This article was submitted Jun. 10, 2011, and was accepted Jul. 1, 2011)

INTRODUCTION

Imaging techniques such as computed tomography (CT), magnetic resonance imaging (MRI) and ultrasound imaging have been extensively used to study the lumbar multifidus muscle. Recently, these techniques have been successfully applied to measure muscle thickness and cross-sectional area in studies of muscular atrophy or hypertrophy. It has been reported that the spinal muscle cross-sectional area differs between healthy subjects and patients with chronic low back pain (CLBP)[1–3]. Danneels et al. have reported a significant reduction in the thickness of the erector spinae and the multifidus muscles below the L4 vertebral segment in CLBP patients as compared to healthy subjects[4]. In addition, Wallwork et al. reported that CLBP patients show a significant decrease in the muscle cross-sectional area of the multifidus muscles around the vertebral segment at rest and during contraction[5]. In both studies, the multifidus muscle cross-sectional area of CLBP patients was smaller in the lower part of the lumbar spine, indicating atrophy of the multifidus muscles.

It has also been reported that patients with low back pain (LBP) exhibit asymmetry of the back muscles[5,6]. Several studies have determined the muscle cross-sectional areas of the multifidus muscles in asymptomatic healthy subjects, and reported that they are symmetrical at each vertebral level[5,6]. However, Hides et al. found that the muscle cross-sectional area of the multifidus muscles was asymmetric in acute or sub-acute LBP patients with the smaller muscle being on the side ipsilateral to symptom[6].

Furthermore, in a study that compared the symmetry of the multifidus muscle cross-sectional area, patients with unilateral LBP exhibited more severe atrophy of the multifidus muscles at the L4 and L5 vertebral level, ipsilateral to pain symptoms, than patients with bilateral or central LBP. In other words, a marked asymmetry was observed between the symptomatic and the asymptomatic side[5].

Lee noted that the inner unit is limited by the diaphragm (upper part), the pelvic floor muscles (bottom part), the multifidus muscles (connecting each vertebrae), and the TrA (from the dorsum to the ventral side)[7]. It is believed that cooperation between each part of the inner unit raises the internal pressure of the abdominal cavity, thereby ensuring stability of the human trunk. In patients with LBP, the activity of the deep trunk muscles, the TrA, and the multifidus muscles is delayed or reduced during movement of the upper or lower limbs and trunk, hindering the stability of the spine[8–12].

Studies on muscle atrophy in patients with LBP have

Table 1. Characteristics of the subjects

	men	women	total	age (years old)	height (cm)	weight (kg)
the CLBP patients	36	14	50	31.5 ± 8.7	167.7 ± 8.0	65.7 ± 13.4
the healthy subjects	32	18	50	30.2 ± 6.1	168.5 ± 8.7	63.3 ± 13.0

focused on the back muscle group, which includes the multifidus muscles. Reports focusing on the abdominal muscle group, which includes the TrA muscle, are limited. We hypothesized that the thickness of TrA in patients with LBP is decreased similar to the multifidus muscles. In this study, we compared the thickness and asymmetry ratio of the abdominal muscle group between healthy subjects and patients with CLBP.

SUBJECTS AND METHODS

Data were obtained from 50 healthy subjects (32 men and 18 women) and 50 CLBP patients (36 men and 14 women). We defined LBP as pain localized between T12 and the gluteal fold. All the CLBP patients had been experiencing LBP for more than 3 months. The median value of pain measured on a visual analog scale was 4 (range 1–9). We selected healthy subjects reporting no LBP in the past 3 months. The subjects were healthy volunteers. All healthy subjects were physically active, but athletes were not included. All subjects were 20–39 years old. The two study groups were highly comparable with regard to age, height, and weight (Table 1). No significant differences in age, height or weight were found. The exclusion criteria for all subjects included a history of spinal or lower extremity surgery or physical dysfunction, such as acute neurological impairment (acute stroke, Parkinson's disease, and paresis of the lower limbs), or a severe musculoskeletal impairment. All subjects were informed about the nature of this study and provided their written informed consent. Abdominal muscle thicknesses in the transverse plane were measured using real-time B-mode ultrasound imaging (LOGIQ Book Xp; GE Healthcare Japan, Tokyo, Japan). Ultrasound transducers (from 8 MHz) were used to assess the abdominal muscles. We measured the thickness of each muscle to an accuracy of 0.1 mm. Four abdominal muscles on the right and left sides were examined: rectus abdominis, external oblique, internal oblique, and transversus abdominis. The rectus abdominis was measured at 4 cm lateral to the umbilicus. The external oblique, internal oblique and transversus abdominis were measured at 2.5 cm anterior to the axillary line, at the height of the umbilicus (Fig. 1, 2). The measurements were performed with the subjects in the supine position. Recordings were consistently taken at the end of a relaxed expiration (when the respiratory muscles are relaxed). During the examination, care was taken to maintain the same standardized position between subjects and the exact location of the transducer. To improve acoustic coupling, a water-soluble transmission gel was placed over the head of the scanner. The transducer was held perpendicular to the skin surface using the minimum pressure required to achieve a clear image. The thickness of each muscle was measured using on-screen calipers. In addition, the asymmetry ratio was calculated as the difference between the two sides and expressed as a percentage of the smallest thickness.

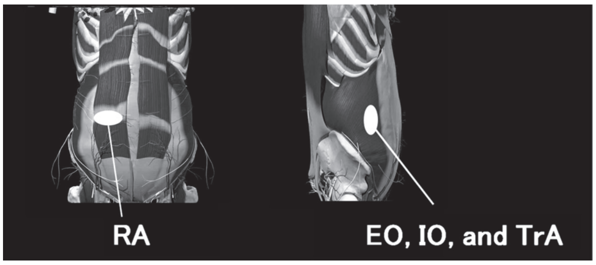
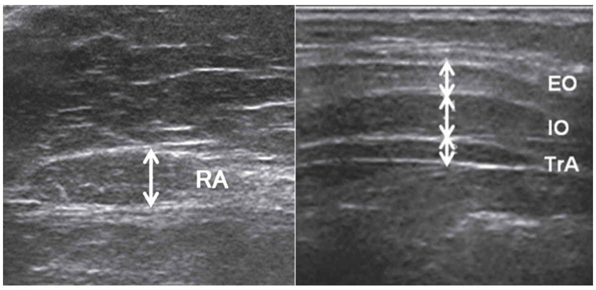


Fig. 1. Points of measurement of muscle thickness
Modified from Primal Pictures (Ovid). The rectus abdominis (RA) was measured at 4 cm lateral to the umbilicus. The external oblique (EO), internal oblique (IO), and transversus abdominis (TrA) were measured at 2.5 cm anterior to the axillary line, at the height of the umbilicus.



RA EO, IO, and TrA

Fig. 2. Ultrasound imaging of rectus abdominis (RA), external oblique (EO), internal oblique (IO), and transversus abdominis (TrA). The transducer was held perpendicular to the skin surface using the minimum pressure required to achieve a clear image. We drew a vertical line, and measured the thickness of each muscle using on-screen calipers.

Differences in muscle thickness and asymmetry ratio between CLBP patients and healthy subjects were analyzed using the t-test. Values of $p<0.05$ were considered as significant.

RESULTS

The differences in muscle thickness between CLBP patients and healthy subjects are shown in Table 2. Of note,

Table 2. Comparison of muscle thicknesses between chronic low-back pain (CLBP) patients and healthy subjects

(mm)	RA	EO	IO	TrA*
the CLBP patients	11.2 ± 2.0	7.4 ± 1.9	10.1 ± 2.2	3.7 ± 0.8
the healthy subjects	10.9 ± 1.8	7.4 ± 2.0	10.8 ± 3.1	4.2 ± 1.2

**p<0.01, *p<0.05 compared with healthy subjects. CLBP patients had significantly smaller TrA muscle thicknesses than healthy subjects.

Table 3. Comparison of asymmetry ratios between chronic low-back pain (CLBP) patients and healthy subjects

(%)	RA	EO	IO	TrA**
the CLBP patients	9.8 ± 9.0	13.8 ± 10.9	14.5 ± 13.0	16.4 ± 2.1
the healthy subjects	8.0 ± 6.0	13.0 ± 8.5	10.1 ± 8.1	8.4 ± 7.5

**p<0.01, *p<0.05 compared with healthy subjects. CLBP patients had significantly heigher the TrA asymmetry ratios than healthy subjects.

CLBP patients (3.7 ± 0.8 mm) had significantly lower TrA muscle thicknesses than healthy subjects (4.2 ± 1.2 mm) ($p<0.05$).

The differences in muscle symmetry between CLBP patients and healthy subjects are shown in Table 3. Asymmetries were more evident in CLBP patients than in healthy subjects for all the muscles analyzed. Consistent with the results of muscle thickness, the TrA asymmetry was higher in CLBP patients (16.4 ± 12.1%) than in healthy subjects (8.4 ± 7.5%) ($p<0.01$).

DISCUSSION

In this study, we compared muscle thickness in two groups to clarify the differences in abdominal muscle thickness between CLBP patients and healthy subjects. There were significant decreases in the thickness of the TrA of CLBP patients. In addition, the asymmetry ratio of the TrA was significantly higher in CLBP patients than in healthy subjects. However, we did not observe any significant differences in muscle thicknesses or asymmetry ratios for the other abdominal muscles.

Bergmark[13] classified the trunk muscles into local and global muscle systems. The primary function of the local muscle system is the mechanical stability of the spine. The global muscle system is comprised of the superficial and relatively large trunk muscles. The global muscle system, e.g., rectus abdominis, the external and internal oblique muscles, is involved in the stability of the trunk as well as bending and rotation movements of the trunk. The local muscle system, e.g., multifidus muscles and transversus abdominis muscle, has an important role in stabilizing the lumbar spine[13–15]. It also has roles in supporting stability in response to external load, separately controlling each vertebra, and deciding the direction of the spinal column.

The local muscle system has a small moment arm in comparison with the global muscle system, which implies a disadvantage in terms of external force**.** However, the local muscle system controls each spinal segment. Therefore, when the local muscle system and the global muscle system are in imbalance as a result of attenuation of the local muscle system or hyperactivity of the global muscle system, the spine is rendered unstable and may become damaged or cause pain. In this study, the thickness of the TrA, a local muscle, of CLBP patients was significantly decreased. We hypothesize that CLBP patients exhibit atrophy of the TrA because of a contractile dysfunction, which hinders trunk stability.

Furthermore, the asymmetry ratio of the abdominal muscle group thickness was higher in CLBP patients than in healthy subjects, significantly so for the TrA. Previous studies have highlighted the importance of the TrA muscle in support, stability, and protection of the lumbar spine. It has been proposed that TrA may contribute to lumbopelvic stability by regulating intra-abdominal pressure and fascial tension. We suggest that trunk stability might also be achieved by co-contraction of the TrA on both sides of the trunk. A previous study suggested there is a potential abnormality when right and left asymmetry characteristics of the multifidus muscles are more than 10%[16]. Based on the asymmetry ratio of the TrA of the healthy subjects participating in this study, we propose the same for the TrA.

This study had several limitations. One limitation was measurement of the muscle thickness as the muscle size of abdominal muscles. In general, muscle cross-sectional area is thought to more accurately reflect muscle size. However, our measurement values did not reflect the longitudinal axis because we took measurements in only one dimension (transverse axis). Also, this being a comparative study, it was not possible to ascertain whether amyotrophy was a cause or a consequence of LBP. In the future, time-dependent research will be needed to determine more effective treatments for and the prevention of LBP.

In this study, we demonstrated that the TrA muscle thickness is significantly smaller in CLBP patients than in healthy subjects. Furthermore, in asymmetry of the muscle thickness, there was a significant difference between CLBP patients and the healthy subjects only for the TrA; significant differences were not observed for the other abdominal muscles. The TrA plays an important role in the stability of the lumbar vertebral column. These results suggest that muscle atrophy and asymmetry of the TrA might be related to CLBP.

REFERENCES

1) Kamaz M, Kireşi D, Oğuz H, et al.: CT measurement of trunk muscle areas in patients with chronic low back pain. Diagn Interv Radiol, 2007, 13: 144–148.
2) Hyun JK, Lee JY, Lee SJ, et al.: Asymmetric atrophy of multifidus muscle in patients with unilateral lumbosacral radiculopathy. Spine, 2007, 32: E598–E602.
3) Hides J, Gilmore C, Stanton W, et al.: Multifidus size and symmetry among chronic LBP and healthy asymptomatic subjects. Man Ther, 2008, 13: 43–49.
4) Danneels LA, Vanderstraeten GG, Cambier DC, et al.: CT imaging of trunk muscles in chronic low back pain patients and healthy control subjects. Eur Spine J, 2000, 9: 266–272.
5) Wallwork TL, Stanton WR, Freke M, et al.: The effect of chronic low back pain on size and contraction of the lumbar multifidus muscle. Man Ther,

2009, 14: 496–500.
6) Hides JA, Strokes MJ, Saide M, et al.: Evidence of lumbar multifidus muscle wasting ipsilateral to symptoms in patients with acute/subacute low back pain. Spine, 1994, 19: 165–172.
7) Lee D: The Pelvic Girdle: An Approach to the Examination and Treatment of the Lumbo-Pelvic-Hip Region, 2nd edition, Philadelphia: Churchill Livingstone, 1999.
8) Hodges PW, Richardson CA: Delayed postural contraction of transversus abdominis in low back pain associated with movement of the lower limb. J Spinal Disord, 1998, 11: 46–56.
9) Hodges PW, Richardson CA: Altered trunk muscle recruitment in people with low back pain with upper limb movement at different speeds. Arch Phys Med Rehabil, 1999, 80: 1005–1012.
10) Hodges PW, Richardson CA: Inefficient muscular stabilization of the lumbar spine associated with low back pain. A motor control evaluation of transversus abdominis. Spine, 1996, 21: 2640–2650.
11) Hodges PW, Moseley GL, Gabrielsson A, et al.: Experimental muscle pain changes feedforward postural responses of the trunk muscles. Exp Brain Res, 2003, 151: 262–271.
12) Ferreira PH, Ferreira ML, Hodges PW: Changes in recruitment of the abdominal muscles in people with low back pain: ultrasound measurement of muscle activity. Spine, 2004, 29: 2560–2566.
13) Bergmark A: Stability of the lumbar spine. A study in mechanical engineering. Acta Orthop Scand Suppl, 1989, 230: 1–54.
14) Richardson C, Jull G, Hodges PW, et al.: Therapeutic Exercises for Spinal Segmental Stabilization in Low Back Pain: Scientific Basis and Clinical Approach, 1998, Churchill Livingstone.
15) Hodges PW: Is there a role for transversus abdominis in lumbo-pelvic stability? Man Ther, 1999, 4: 74–86.
16) Stokes M, Rankin G, Newham DJ: Ultrasound imaging of lumbar multifidus muscle: normal reference ranges for measurements and practical guidance on the technique. Man Ther, 2005, 10: 116–126.