

Comparison of Changes in Abdominal Muscle Thickness Using Ultrasound Imaging during the Abdominal Drawing-in Maneuver Performed by Patients with Low Back Pain and Healthy Subjects

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Abstract. [Purpose] The purpose of this study was to identify the changes in abdominal muscle thickness during the abdominal drawing-in maneuver (ADIM) in patients with low back pain (LBP) and healthy subjects. [Subjects] The subjects were 40 volunteers: 20 healthy subjects and 20 patients with LBP. [Methods] In sitting, the subjects performed rest for 10 seconds and ADIM for 10 seconds as a set with 3 repetitions. Thickness measurements of the abdominal muscles were performed in triplicate while subjects were at rest and performing ADIM using B-mode ultrasound imaging. [Results] In patients with LBP there was no significant change in the thickness of the external oblique (EO), whereas the EO of healthy subjects significantly decreased during ADIM. The thickness of the internal oblique (IO) and transversus abdominis (TrA) significantly increased during ADIM as compared to at rest in both groups. [Conclusion] These findings suggest that ADIM increase the thickness of the deep abdominal muscles and that the change in the thickness of the deep abdominal muscles of patients with LBP increase less than that of healthy subjects. Therefore, ADIM should be used to train the deep abdominal muscles of patients with LBP.

Key words: Abdominal drawing-in maneuver, Thickness changes of abdominal muscles, Low back pain

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INTRODUCTION

Over 80% of the population has experienced low back pain (LBP) at least once during their lifetime¹⁾. Despite various pathologic factors that induce LBP, 85% of patients with LBP are classified as non-specific LBP which include LBP caused by lumbopelvic instability^{2, 3)}. Repeated injury of the spine can cause weakness of the paraspinal muscles with deep muscle atrophy and problem of the muscles causes chronic LBP, increasing the instability of the spine^{4, 5)}. To minimize repeated stimulation of the lumbar spine, functional stable movement is needed, but in unstable conditions, the movement of the spine increase the instability and changes the quantity and quality of movement⁶⁾.

The transversus abdominis (TrA) is a wide and flat muscle that is layered through the lateral abdominal wall, and it performs the primary function of stabilizing the lumbar spine by increasing internal abdominal pressure⁷⁾. Normally, the primary function when performing fast movements of the upper or lower limbs, is for the agonist of the upper or lower limbs to contract after the lumbar portion has been stabilized by prior contraction of the TrA and multifidus^{8, 9)}. However, when patients with chronic LBP perform fast movements of the upper or lower limbs, deep muscles in the lumbar portion are activated late in the initial activation or

problems due to weakness and atrophy^{10, 11)}.

Hides et al.¹²⁾ suggested that 90% of acute LBP patients experience a natural decrease of pain within 2–3 weeks, however, 60%–80% of the patients relapse within a year and the weakness of deep abdominal muscles make recovery difficult for patients with LBP. Therefore, they suggested that patients need muscle reeducation in order to be able to induce contractions of the deep muscles in the lumbar portion and to recover the normal thickness of the muscles and to decrease the relapse ratio of LBP. Therefore, many researchers have suggested the abdominal drawing-in maneuver (ADIM) for stabilizing the abdominal muscles and suggested teaching ADIM to patients with LBP. They have suggested that ADIM should be performed to draw in the lower abdomen. To accurately perform ADIM, the TrA should be contracted by selective movement in the order of the rectus abdominis, the external oblique (EO), and finally the internal oblique (IO) muscles^{13–15)}.

Hodges and Richardson¹⁶⁾ suggested using rehabilitative ultrasound imaging (RUSI), a non-invasive and low-cost method, to observe the changes in the deep abdominal muscles. Hides et al.¹²⁾ stated that it was possible to see the muscle thickness change during selective muscle contraction using RUSI. Hodges et al.¹⁰⁾ reported that ultrasound imaging evaluation is useful for finding the change in

length and thickness of abdominal muscles between the rest and contraction periods when comparing surface electromyogram with RUSI.

Therefore, in this study, we attempted to measure the changes of the thickness of the abdominal muscles between rest and ADIM and calculate the difference of the changes of the thickness between patients with LBP and healthy subjects.

SUBJECTS AND METHODS

The subjects were 20 patients with LBP and 20 healthy subjects. The inclusion criteria for the patients with LBP were being diagnosed with non-specific LBP by a medical doctor, having persistent LBP over the last 3 months, no history of trauma or surgical operation in the lumbar portion, having pain at the 4–6 level on the visual analogue scale, and a level of 30%–50% on the Korean version of the Oswestry disability index. The inclusion criteria for healthy subjects were not experiencing LBP within the last 3 months, having no pathological disorder in the lumbar portion and no history of trauma or surgical operation in lumbar portion^{17, 18)}.

This study used ADIM to draw in and hold the lower abdomen with expiration in a sitting position on a chair. Subjects rested for 10 seconds and performed ADIM for 10 seconds in a set with 3 repetitions (Fig. 1)^{10, 18)}. Before progressing to the main experiment, the subjects were educated in the method of ADIM and practised 3 sets to decrease errors from incorrect performance.

To measure the thickness of the abdominal muscles, ultrasound equipment (LOGIQ Book XP, GE Healthcare, USA) with a 7.5 MHz linear probe was used, and the image was set to the B-mode with a depth of 4 cm. The probe was placed in the middle, between the iliac crest and the edge of the rib, to observe the abdominal muscles^{10, 19, 20)}. Drawing a 15 mm horizontal line from the TrA aponeurosis and a vertical line to intersect this allowed measurement of the thickness of the abdominal muscles (Fig. 2)²¹⁾.

For statistical analysis and data analysis, SPSS 12.0 for Windows was used. One-way analysis of variance with between subjects was used to identify interaction between muscle and group. The paired t-test was used to compare abdominal muscle thickness between rest and ADIM in each group. The independent t-test was used for comparison between the LBP and healthy subject groups; the level of significance was chosen as 0.01.

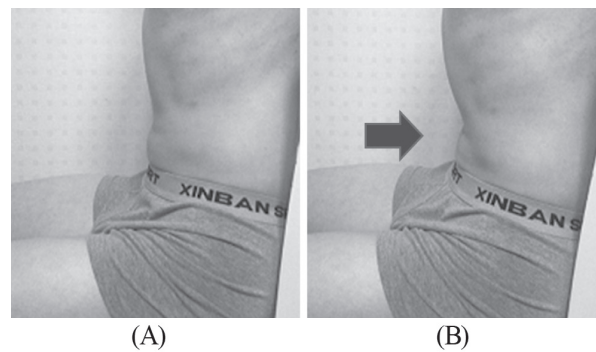


Fig. 1. Method of ADIM. (A) during rest, (B) during ADIM.

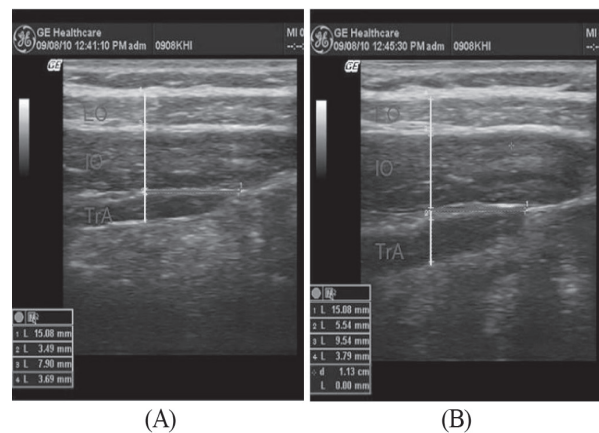


Fig. 2. Ultrasound image of abdominal muscles and measurement of thickness. (A) during rest, (B) during ADIM.

RESULTS

Interaction between muscle and group showed a significant difference ($p < 0.01$).

As shown in Table 1, in patients with LBP, there was no significant change in thickness of the EO, and the thickness of the IO and TrA significantly increased during ADIM as compared to at rest ($p < 0.01$). In healthy subjects, the thickness of the EO significantly decreased during ADIM ($p < 0.01$) while the thickness of the IO and TrA significantly increased during ADIM compared to when at rest ($p < 0.01$).

Comparing the rate of thickness change between patients with LBP and healthy subjects, the EO decreased less for

Table 1. Thickness changes of abdominal muscles (mm)

Muscles	Patients with LBP		Healthy subjects	
	Rest	ADIM	Rest	ADIM
EO	4.77 ± 0.54^a	$4.76 \pm 0.53^*$	4.88 ± 0.80	$3.93 \pm 0.88^*$
IO	7.76 ± 0.61	$10.60 \pm 0.50^*$	7.85 ± 0.80	$12.90 \pm 0.84^*$
TrA	4.71 ± 0.70	$6.70 \pm 0.78^*$	4.95 ± 0.99	$9.78 \pm 0.90^*$

^aMean(mm) \pm SD, * $p < 0.01$, ADIM: abdominal drawing-in maneuver, EO: external oblique, IO: internal oblique, TrA: transverses abdominis.

patients with LBP than for healthy subjects ($p < 0.01$), and the IO and TrA increased less for patients with LBP than for healthy subjects ($p < 0.01$).

DISCUSSION

This study compared the thickness of abdominal muscles between rest and ADIM. The thickness of the IO and TrA significantly increased during ADIM for all subjects, but the thickness of the EO significantly decreased only in the healthy subjects.

These results agree with those of Teyhen et al.¹⁵⁾ who reported no change in thickness of the EO and increases in the thickness of the IO and TrA during ADIM in patients with LBP. They also support of supposition of Hodges et al.¹⁰⁾ who suggested the thickness of the EO would decrease and the thickness of the IO and TrA would increase during ADIM in healthy subjects.

The rate of thickness change between patients with LBP and healthy subjects was also compared, and the rate of thickness change of the IO and TrA increased less for patients with LBP than for healthy subjects. These results agree with those of Beazell et al.²²⁾ and Mannion et al.¹⁷⁾ who reported that the thickness change of the IO and TrA increased less for patients with LBP than for healthy subjects during ADIM. Teyhen et al.²³⁾ also reported that the thickness change of the TrA increased less for patients with LBP than for healthy subjects during ADIM, but that there was no difference in the thickness change of the IO between patients with LBP and healthy subjects.

As this study only attempted to identify immediate thickness changes of the abdominal muscles during ADIM, we could not analyze the long-term effects of ADIM. Moreover, as the subjects were in their 20s and had only mild pain levels, the findings of this study cannot be generally applied to all patients with LBP. Therefore, future studies are needed to investigate the long-term effects of the performance of periodic ADIM by patients with LBP of various age groups and pain levels.

Our present findings suggest that ADIM increases the thickness of the deep abdominal muscles and that the change in the thickness of the deep abdominal muscles of patients with LBP increased less than those of healthy subjects. Therefore, ADIM should be used to train the deep abdominal muscles of patients with LBP.

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