

Effects of Different Types of Contraction in Abdominal Bracing on the Asymmetry of Left and Right Abdominal Muscles

SUNG-HYUN PARK, BSc, PT¹⁾, MIN-YOUNG SONG, MS, PT^{2)*}, HYEON-JI PARK²⁾, JI-HYUN PARK²⁾, HYUN-YOUNG BAE²⁾, DA-SOM LIM²⁾

¹⁾ Department of Physical Therapy, College of Health Sciences, Catholic University of Pusan, Republic of Korea

²⁾ Department of Physical Therapy, Dong-Eui Institute of Technology: Busan, Republic of Korea

Abstract. [Purpose] The purpose of this study was to investigate the effective strength levels of abdominal muscle contraction using the bracing contraction method. [Subjects] The experiment was conducted with 31 healthy male (M=15) and female (F=16) adults attending D University in Busan; all participants had less than obesity level BMI (BMI<30). [Methods] Bracing contraction was performed by the subjects in the hook-lying position at maximum and minimum pressure levels, five times each, using a Pressure Biofeedback Unit (PBU), and the mean measurement value was calculated. The maximum pressure level was set at 100% and the half maximum pressure level was set at 50%. Each subject's left and right abdominal muscle thicknesses were then measured by ultrasound imaging in each state: at rest, 100% contraction, and 50% contraction. [Results] No significant differences were found between the left and right sides of the transversus abdominis (TrA) at rest, 50%, or 100% contraction. The external oblique abdominis (EO) and internal oblique abdominis (IO) showed no significant difference at rest or at the 50% contraction. However, a significant difference was noted at 100% contraction for the EO and IO. [Conclusion] Application of abdominal contraction using bracing can achieve symmetry in the left and right abdominal muscles at less than the maximum contractile strength. The occurrence of asymmetry in the left and right abdominal muscles at the maximum contractile strength suggests that the most suitable contractile strength in this exercise is less than the maximum contractile strength.

Key words: Abdominal bracing, Symmetry, Ultrasound imaging

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INTRODUCTION

Trunk muscle strength plays an important role in controlling posture, stability, and trunk movement and is an essential element in the performance of movements of the extremities^{1,2)}. The muscles used to achieve trunk stability are the trunk posterior muscles which are composed of a superficial layer muscle group (trapezius, latissimus dorsi, rhomboids, etc.), a middle layer muscle group (serratus posterior superior, inferior, etc.), a deep layer muscle group (the erector spinae, transverse spinal, and short segmental groups), and anterior and lateral trunk muscles composed of abdominal muscles (rectus abdominis, internal oblique abdominis, external oblique abdominis, and transverse abdominis). The active muscular strength of these muscles plays a primary role in spinal stabilization³⁾, and weakening of these muscles leads to instability of the trunk and low back

pain⁴⁾. In addition, instability of the trunk could result in a decreased ability to perform various exercise movements⁵⁾. J. Gibson et al. stated that in order to have enough muscular activity during upper limb movement, dynamic stability of the spine needs to be established⁶⁾. Dynamic trunk stability especially involves the anterior and lateral trunk muscles, or abdominal muscles. Consequently, observational studies of these abdominal muscles are being actively conducted⁷⁾. Ultrasound imaging has been widely used to examine the change in or ratio of abdominal muscle thicknesses in many research studies⁸⁾. In addition, many studies have investigated the application of exercise intervention to determine the optimal degree of contraction^{9, 10)}. However, since humans perform many asymmetrical and repetitive tasks, the tendency for a dominant hand occurs, and differences in muscular strength and morphology appear in the left and right side muscles¹¹⁾. Accordingly, the abdominal muscles are expected to show asymmetrical activation, but studies of the asymmetry of the left and right abdominal muscles are lacking. Rankin G et al. measured the changes in the thicknesses of the abdominal muscles of general subjects in a stable state, while Mannion et al. measured thickness changes in contraction during abdominal hollowing^{8, 9)}. However, both of these studies had limitations: the first be-

*Corresponding author. Min-Young Song (E-mail: ditsong@dit.ac.kr)

Table 1. General characteristics of the subjects

Gender	N	Age (years)	Height (cm)	Weight (kg)	BMI*
Male	15	21.5±2.3	175.3±5.5	66.5±6.8	21.7±2.2
Female	16	21.1±2.2	132.9±5.6	54.4±7.4	20.5±2.3

Mean ± SD. *BMI = weight (kg)/height (m)*height (m)

cause the measurements were made in a stable state, and the second because hollowing occurred, which elicits the selective contraction of the transverse abdominis. Therefore, the aim of the present study was to compare contraction in the left and right abdominals by applying bracing, which elicits overall contraction of the abdomen.

SUBJECTS AND METHODS

This study was conducted with 31 healthy male and female adults, who were attending D University in Busan. Exclusion criteria included a BMI at the obesity level, any specific pain in the lumbar area within the past 3 months, and any history of mental diseases, or muscular skeletal diseases that would be provoked by participating in the experiment. The subjects who met the above criteria participated in the experiment voluntarily, and provided their informed consent. Before participating in the experiment, subjects were informed of the details of the experiment and the pain that might possibly result from the experiment. The general characteristics of the subjects are shown in Table 1.

A survey was conducted prior to the experiment to determine the dominant hand and only those who answered that the right hand was their dominant hand were selected as subjects. The bracing exercise used in this study was performed by the subjects while they were in a supine position with the pelvis and trunk aligned and bent legs. The subjects contracted the lumbar-pelvic region imagining they were expanding the abdominal area in every direction, as if reacting to the abdomen being hit, and maintained natural respiration¹²). A prior training session was conducted before starting the experiment, in order to reduce the error range of the experimental results due to inadequate performance proficiency and to improve reliability. A Pressure Biofeedback Unit (Chattanooga Group Inc. Hixson, TN37343, USA) was used to measure the maximum pressure five times for each subject, and the mean value was calculated. This mean value was used as the value of 100% contraction, and it was also set as the base point for the 50% contraction measurement. The contraction of the abdominal muscles was observed using a LOGIQ Book XP (GE Healthcare Product, Milwaukee, WI, USA) system. A standardized ultrasound image was obtained by placing the probe at the midpoint of the costal cartilage and the iliac crest¹⁰). Using B (brightness)-mode ultrasound, the transducer was positioned 2.5 cm anteromedially to the mid-point between the iliac crest and the costal margin on the mid-axillary line, where the fascial boundaries between TrA, OI and OE and the superior edge of the TrA fascia lie parallel¹³). The difference between the muscle thickness on the left and right sides was determined by the paired t-test, and significance was accepted for values of $p < 0.05$. This study was approved

Table 2. Comparison of abdominal muscle thicknesses of each of the left and right side (cm)

		Right	Left
TrA	Resting	0.4±0.1	0.4±0.1
	50% Cont.	0.5±0.2	0.5±0.2
	100% Cont.	0.6±0.4	0.6±0.3
EO	Resting	0.5±0.1	0.5±0.2
	50% Cont.	0.6±0.1	0.5±0.1
	100% Cont.*	0.8±0.2	0.6±0.2
IO	Resting	0.8±0.3	0.8±0.3
	50% Cont.	0.9±0.2	0.8±0.2
	100% Cont.*	1.0±0.3	0.9±0.2

* $p < 0.05$. Cont.: contraction, TrA: transversus abdominis, EO: external oblique abdominis, IO: internal oblique abdominis

by the Human Subject's Research Ethics Committee of Catholic University (CUPIRB-2014-004) of Pusan.

RESULTS

The asymmetry in the left and right abdominal muscles was measured at maximum and 50% contraction. The changes in the thicknesses before and after the contraction are shown in Table 2. The anatomical characteristics of abdominal muscles may reduce the reliability of thickness measurements made using ultrasound imaging. Therefore, during the experiment, each subject was measured at three different times of the day to obtain an absolute value. The differences in the abdominal muscle thicknesses of each of the left and right abdominal muscles at rest, at 50% contraction, and at maximum contraction are shown in Table 2. As shown in Table 2, no significant differences were evident for the transverse abdominis (TrA). The measured values of the external oblique abdominis (EO) and the internal oblique abdominis (IO) at rest and at 50% contraction also showed no significant differences. However, the measurements of the EO and IO at 100% contraction showed significant differences ($p < 0.05$).

DISCUSSION

In this experiment, the measured thickness values of the right IO (1.03, 0.86, and 0.17) were larger and the thicknesses of the EO (0.76, 0.65, and 0.11) were also larger on the right side. This might be because the subjects were all right-handed, resulting in the right abdominal muscles being thicker. In contrast, the TrA showed no differences between the left and right sides when measured at rest, at 100% contraction, or at 50% contraction in the bracing ex-

ercise. This exercise enhances the activity of global muscles so the contraction level of the local muscles, like those located more to the central part, such as TrA muscle, etc., is insignificant. Mannion et al. used a hollowing exercise to determine the level of asymmetry between the left and right abdominal muscles, and reported a thickness difference between the left and right TrA muscles⁹. Therefore, the reason for the difference between the results of our study and those of Mannion's is assumed to be differences in methodology⁹. Apart from these studies on the abdominal muscle thickness, studies related to low back pain are also being actively pursued¹⁴. Kang et al. chose the right side for abdominal muscle measurement, and Ha et al. applied an abdominal drawing-in exercise after a bridging exercise, but only presented the increases in the abdominal internal oblique and abdominal external oblique, which simply stabilize the trunk, without indicating on which side the abdominal muscle was measured^{15, 16}. Kwon et al. also did not state on which side the abdominal muscle was measured with ultrasound imaging during a hollowing exercise, and only addressed the reliability of ultrasound imaging for measuring the contraction of the abdominal muscles¹⁷. In the present study, the abdominal muscle contraction was uneven when performing the bracing exercise. Thus, future studies of the relationship of muscle thickness asymmetry with low back pain should consider the level of asymmetry of contraction in the left and right muscles during an abdominal bracing exercise. The fact that the experiment was conducted on adults in their 20s presents limitations regarding the application of these results to subjects older than their 20s, or those who have smaller muscles and lower muscle contraction. Also, since the subjects were healthy, the result may have limited applicability to left and right asymmetry in subjects with impaired trunk stability, or those with low back pain.

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