

Effects of three spinal stabilization techniques on activation and thickness of abdominal muscle

Byeong-Jo Kim, Su-Kyoung Lee*

Department of Physical Therapy, College of Nursing and Healthcare Science, Dong-Eui University, Korea

In this study, we examine the thickness of the abdominal muscle and its activity during the performance of the three drawing-in methods. The subjects were 20 healthy male and female students in their 20s. Using ultrasonography and electromyography, the experimenter measured the thickness of the transversus abdominis (TrA) muscle, internal oblique (IO) muscle and external oblique (EO) muscle. The ultrasonography measurements for the drawing-in manoeuvre (DI), abdominal bracing, and posterior pelvic tilt (PT) techniques were 0.64 ± 0.20 , 0.54 ± 0.15 , and 0.46 ± 0.12 , respectively, with significant differences for the TrA. The electromyography results of the DI, SA, and PT techniques

were 4.35 ± 1.72 , 3.00 ± 1.48 , and 2.70 ± 1.52 , respectively, for the IO. There was a significant difference in the DI, SA, and PT techniques for the EO (5.10 ± 3.30 , 3.85 ± 3.89 , 2.25 ± 1.29 , respectively). The DI method activated the oblique abdominal muscles, but there was no great change in their thickness; the TrA, however, was selectively strengthened through changes in its thickness.

Keywords: Spinal stabilize, Drawing-in manoeuvre, Abdominal muscle thickness, Abdominal muscle activation


INTRODUCTION

Spinal stability is important for prevention and treatment of lumbar damage (McGill, 2001), and requires concurrent activity of all trunk muscles around the lumbar region (Lehman et al., 2005; Marshall and Murphy, 2005). The spinal muscles used for spinal stability are divided into global muscles, which are large muscles located on the surface of the abdomen and lumbus and are engaged in overall stability, and local muscles, which are intrinsic muscles situated deep in the abdomen and lumbus, are directly connected to the spine and engage in fine adjustment of the spine and stability of the spinal segments (Bergmark, 1989). Concurrent activity between the global and local muscles maintains the spine in a stabilized condition (Marshall and Murphy, 2005; Stevens et al., 2007), which is essential for physical posture, balance and recovery of stability (Duarte et al., 2002). Loss of this trunk control function is a factor for body misalignment, decrease in upper and lower extremity motor function and impairment in balance ad-

justment, gait ability and activities of daily living (Verheyden et al., 2006). Therefore, trunk control can be used to evaluate balance, gait and recovery in daily routines (Hsieh et al., 2002).

Stabilization exercises are conducted to adjust force when the patient's posture is unstable and to control movements consciously and unconsciously so that the spine maintains a neutral position, which is the best posture for the spine to adjust to an external load. Both global trunk and segment deep muscles play critical roles in providing stability and maintaining the upright posture (Kisner and Colby, 2016), and is an intervention that prevents repetitive micro-damage of the muscles around the spine and degenerative change of the spinal joints (Richardson et al., 1999). It is used as an essential therapeutic method for low-back pain patients to recover trunk control ability (Maffey-Ward et al., 1996).

The three methods used to activate the stabilizer muscle system in the lumbar vertebra include a drawing-in manoeuvre (DI) to pull the navel towards the spine, abdominal bracing (AB) to splay the lumbar region laterally by fixing the abdominal muscles and a

*Corresponding author: Su-Kyoung Lee  <http://orcid.org/0000-0002-4916-2188>
Department of Physical Therapy, College of Nursing and Healthcare Science, Dong-Eui University, 176 Eomgwangno, Busanjin-gu, Busan 47340, Korea
Tel: +82-51-890-4223, Fax: +82-505-182-6881, E-mail: ptlsk@deu.ac.kr
Received: January 9, 2017 / Accepted: April 15, 2017

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posterior pelvic tilt (PT) to make the pelvis tilt posteriorly in a positive manner and the lumbar vertebra even. Among them, the first method activates the transversus abdominis (TrA), minimizing contraction of the oblique abdominal or not contracting the muscle (Kisner and Colby, 1999). As a technique to measure this, ultrasonography is a useful noninvasive tool to measure the size and activity conditions of deep trunk muscles, such as the TrA and multifidus (Kwon et al., 2011). Ultrasonography can observe an object directly on a real-time basis and enables fast measurement and repetitive tests without the risk of radiation exposure (Hedrick et al., 1995; Rumack et al., 1998). In this study, we examine the thickness of the abdominal muscle and its activity during the performance of the three drawing-in methods.

MATERIALS AND METHODS

Participants

The subjects were 20 young male university students aged between 21 and 30 years. The procedures of this study were harmless to the human body. All subjects read and signed a written consent form. They listened to an account of the study's purpose and methods, understood the study content and consented to participate in this experiment (Table 1).

Design

Using ultrasonography and electromyography, the experimenter measured the thickness of the TrA, internal oblique (IO) and external oblique (EO) muscle. Also measured was the activity of the IO and EO while the subject was performing the three drawing-in methods. The three spinal stabilization methods—DI, AB, and PT—were performed 3 times randomly. Each motion was maintained for 5 sec.

Drawing-in manoeuver: The subject lay in a supine position on a bed with the knee joint flexed at 90°. Both hands were placed beside the head, and the eyes were fixed on one point on the ceiling. As the subject breathed out, the navel was posteriorly pulled up.

Abdominal bracing: In the same posture as described above, the

subject breathed out and pulled in the navel with constant pressure.

Posterior pelvic tilt: In the same posture as described above, the subject breathed out, had the lumbus evenly on the bed and the pelvis was pulled back.

Measurements and statistical analysis

Changes in the thickness of the IO and EO were analysed using ultrasonography (F31, Hitachi-Aloka Medical., Tokyo, Japan) while the subjects were resting and in a state of three draw-in method. Ultrasonography was conducted by referring to previous studies. Ultrasonographic imaging was obtained using a 10-MHz linear probe (UST-5413), with the midpoint of the transducer placed along the midaxillary line in the transverse plane just above the right iliac crest (Hodges et al., 2003). A wireless surface electromyography (TeleMyo 2400T, Noraxon Co., Scottsdale, AZ, USA), was used to obtain measurements. Each muscle's surface electrode was attached to the middle area of the belly where the muscles were most activated in parallel with the direction of the muscle fibres in a manual muscle test. The interval between the two electrodes was maintained at 2 cm to compare differences in potential between the two electrodes. All raw data from the electromyograph were transformed into root mean square and analysed as described below. In order to compare electromyography signals between subjects and between muscles, a standardization process was performed that assumed muscle contraction of certain motions as the reference voluntary contraction (RVC) and used the %RVC based on the RVC (Cram et al., 1998) to standardize electromyography signals. A one-way analysis of variance (ANOVA) was utilized to examine changes in the thickness of abdominal muscles and changes in muscle activity when abdominal drawing-in techniques were performed. As a *post hoc* test, Fisher least significant difference (LSD) test was carried out. Statistical processing for data analysis was conducted using PASW Statistics ver. 18.0 (SPSS Inc., Chicago, IL, USA), and the significance level to verify statistical significance was set at 0.05.

In this study, the experiment was conducted on a single force plate to examine movements and ground reaction forces in the feet while the subjects were standing up from sitting (BP600400, AMTI Co., Watertown, MA, USA), and data on vertical, forward-and-backward and side-to-side ground reaction forces were obtained. A one-way ANOVA approach was used to compare the changes according to the three angles and heights. Fisher LSD *post hoc* analysis was performed and the statistical significance level was set to 0.05.

Table 1. Characteristics of study participants (n=20)

Characteristic	Value
Sex, male:female	5:15
Age (yr)	20.95±1.14
Height (cm)	165.10±8.46
Weight (kg)	57.10±8.94

Values are presented as number or mean ± standard deviation.

Table 2. Comparison of abdominal muscle thickness according to three spinal stabilization techniques

	DI	AB	PT	F	P-value
TrA	0.64±0.20	0.54±0.15 [†]	0.46±0.12 [‡]	6.286	0.003*
IO	0.88±0.40	0.83±0.36	0.80±0.25	0.325	0.724
EO	0.42±0.09	0.40±0.10	0.41±0.16	0.098	0.907

Values are presented as mean ± standard deviation.

DI, drawing-in; AB, abdominal bracing; PT, pelvic posterior tilt; TrA, transversus abdominis; IO, internal oblique; EO, external oblique.

* $P < 0.05$. [†]Significant difference between DI and AB ($P < 0.05$). [‡]Significant difference between DI and PT ($P < 0.05$).

Table 3. Comparison of abdominal muscle activation according to three spinal stabilization techniques

	DI	AB	PT	F	P-value
IO	4.35±1.72	3.00±1.48 [†]	2.70±1.52 [‡]	6.169	0.004*
EO	5.10±3.30	3.85±3.89	2.25±1.29 [‡]	4.406	0.017*

Values are presented as mean ± standard deviation.

DI, drawing-in; AB, abdominal bracing; PT, pelvic posterior tilt; IO, internal oblique; EO, external oblique.

* $P < 0.05$. [†]Significant difference between DI and AB ($P < 0.05$). [‡]Significant difference between DI and PT ($P < 0.05$).

RESULTS

The ultrasonography measurements for the drawing-in, AB and PT techniques were 0.64 ± 0.20 , 0.54 ± 0.15 , and 0.46 ± 0.12 mm, respectively, with significant differences for the TrA muscle (Table 2). The *post hoc* test showed a significant difference between the drawing-in and AB techniques and between the drawing-in and PT techniques. The electromyography results of the drawing-in, AB, and PT techniques were $4.35\% \pm 1.72\%$, $3.00\% \pm 1.48\%$, and $2.70\% \pm 1.52\%$ of RVC, respectively, for the IO abdominal. There was a significant difference in the drawing-in, AB, and PT techniques for the EO abdominal ($5.10\% \pm 3.30\%$, $3.85\% \pm 3.89\%$, $2.25\% \pm 1.29\%$ of RVC, respectively) (Table 3). The *post hoc* test showed a significant difference between the drawing-in and AB techniques and between the drawing-in and PT techniques for the IO abdominal and a significant difference between the drawing-in and PT techniques for the EO abdominal.

DISCUSSION

Three techniques are commonly employed in the clinical field to activate abdominal muscles, but their effects are not obvious. In this study, experiments were conducted to minimize activity of the internal and EO and to examine which of the three techniques resulted in the greatest thickness and activity of the TrA. The treatment goal of the drawing-in technique is to activate the TrA, minimizing contraction of the oblique muscles or not contracting those muscles. With coactivation of the TrA and multifidus, the DI technique was more effective than AB and PT (Hodges and

Richardson, 1996). The DI increases internal pressure by moving the abdominal wall inward (Kisner and Corby, 2016), and for this reason is recommended for stabilization training. In the present study, ultrasonography showed significant changes in the thickness of the TrA compared to the internal and EO when using the DI method. Kisner and Colby (2016) also reported that activation of these muscles was minimized or not perceived when surface electrodes were attached to the rectus abdominis and EO prior to using the DI method. AB in contrast with the DI method showed activation of the oblique abdominal and stabilized the global muscles (Richardson et al., 1992). In the present study, activity of DI in both the internal and EO was high using the AB and PT techniques with surface electromyography, and the activity of the TrA significantly increased as shown by ultrasonography. This is judged to be because the activity of the IO and EO changed without changes to their thickness. The PT exercise largely activates the rectus abdominis, which is used for dynamic flexion of the trunk. This muscle is not considered a key stabilization muscle of the spine and is not regarded as important in stabilization training (Hodges and Richardson, 1997). This method is mostly used to perceive movement of the pelvis and lumbar vertebrae; stabilization muscles may be activated if the range of motion of the lumbus by pelvic tilting is spotted and the neutral location or the pelvic functional range of motion is known.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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