Effect of Pelvic Floor Muscle Contraction on Ultrasonographic Thickness of Abdominal Muscles

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Abstract

Introduction: The current study compared the effect of pelvic floor muscle (PFM) contraction on thickness of abdominal muscles during an abdominal hollowing maneuver (AHM), which is a specific contraction of transverse abdominis(TrA)and internal oblique(IO) muscles in healthy and low back pain (LBP) subjects. **Materials and Methods:** Thirty subjects (15 with LBP and 15 without LBP) participated in this study. In ultrasonographic evaluation, the thickness of the TrA and IO muscles in AHM with and without PFM contraction were measured. **Results:** No significant difference was seen in the thickness of abdominal muscles in contraction alone and in combination with PFM contraction during AHM between the two groups. No difference was seen in the thickness of abdominal muscles with and without PFM contraction between the LBP and healthy subjects in AHM. **Conclusions:** Adding PFM contraction had no significant effect on abdominal-muscle contraction in subjects with or without LBP.

Keywords: Abdominal muscles thickness, pelvic floor muscles, Ultrasound image

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Introduction

Based on the theories of spinal column stability where conceptual and clinical models have been formed, different treatment methods have also been analyzed or formed. One theory that has been proposed regarding the onset of low back pain (LBP) is the "stability theory" (1). According to this theory, back injury, and therefore back pain, could be a result of poor control of the spinal structure (2). Since this theory has been modified several times, it has become clear that stability is a dynamic process that includes both static positions and controlled movement.

According to Panjabi (1), three subsystems work together to maintain spine stability; these subsystems are passive, active, and neural. The passive subsystem consists of the vertebrae, discs, and ligaments. The responsibility of the passive subsystem is to monitor spinal motion and position. The muscles and tendons surrounding the spinal column compose the active subsystem. The active and passive subsystems are coordinated by the neural subsystem which consists of the nerves and the central nervous system. Theoretically, an injury, degeneration, or disease could reduce either passive or active stability or both (3). To compensate the muscles, the neural-feedback system would then increase the demand on the muscles (2, 4). The active subsystem can be further subdivided into a local and a global stabilizing system. The local muscles are mainly involved in joint support or stabilization. They are not typically movement producers but provide stability to allow movement of a joint. The major local muscles include the transverse abdominis (TrA), posterior fibers of the internal oblique (IO), the muscles of the pelvic floor (PFM), and the multifidus muscles. The global muscles are predominantly larger and responsible for movement, while the rectus abdominis (RA) and the external oblique (EO) muscles are the most obvious of them (4, 5).

Although the exact mechanism that causes LBP is not well understood, it may be associated with changes in control of the deep trunk muscles. There is evidence that in patients with LBP, both the TrA and the PFM are often very dysfunctional (4, 6-8).

There is a large body of literature demonstrating that during the activation of abdominal muscles, the PFM are active. PFM synergies have been recommended as an important method to promote continence by resisting increased intra-abdominal pressure generated by functional tasks (9). According to these studies, it is possible to stimulate one group of muscles with contracting the other group. In considering the clinical aspect, it can be pointed out that the deficiency of one group can be compensated by the voluntary contractions of the other group. As a result, this theory can be used to treat the weakness of a specific group of muscles, which can be applicable for two groups of people: those with PFM dysfunction, and those who suffer from weakness of the abdominal muscles.

Some researchers have investigated the co-activation of the abdominal and PFM. Most researchers have investigated the response of abdominal muscle to PFM activity, when the abdominal muscles are relaxed, and limited studies have been done regarding the response of the abdominal muscles to PFM activity when the abdominal muscles voluntarily contract. These studies have investigated co-activation of the abdominal muscles and PFM in healthy patients (6, 10, 11) and those with stress urinary incontinence (SUI) (6, 12, 13). It can be concluded that there are several unknown points. To the best of our knowledge, no study has evaluated the co-activation of the abdominal and PFM muscles during voluntary abdominal muscle contraction in healthy and LBP subjects. The purpose of the current study was to compare the thickness of abdominal muscles during an abdominal hollowing maneuver with and without PFM contraction in healthy and LBP subjects.

Material and Methods

Thirty subjects (15 with LBP and 15 without LBP) who were matched in gender, age, body mass index, and physical activity level participated in this study. Each subject read and signed an informed consent form approved by the appropriate ethics review board. All subjects completed a questionnaire recording their gender, age, weight, height, and level of physical activity. Subjects with LBP were included in the study if they had a history of LBP for more than six weeks prior to the study or had on and off back pain and had experienced at least three episodes of LBP, each lasting more than one week, during the year prior to the study. To assess pain intensity, a visual analogue scale (VAS) was used. A VAS score of 2 or less on the day of the test was taken as further inclusion criterion. Subjects without LBP were evaluated and found to have no complaint of any pain or dysfunction in their low back, pelvis, thoracic, or lower extremities. Participants were excluded if they reported a history of spine or abdominal surgery, persistent severe pain, neurological symptoms, osteoporosis, systemic inflammatory disease, severe cardiovascular diseases, acute infection, uncontrolled alcohol/drug abuse, or pregnancy.

Ultrasound imaging: The ultrasonography device used in this study was an imaging unit set in B mode (Ultrasonix-E500, Canada) with a 7.5 MHz linear array transducer. In sonographic evaluation, thickness in the TrA, IO, and EO muscles in abdominal hollowing maneuvers with and without PFM contraction was measured. These measurements were taken from the right side of the abdominal wall. Participants were tested in the crook-lying position with one pillow underneath the knee. The lumbar spine was positioned in a neutral position, and the abdominal wall was exposed. The inferior borders of the rib cage and the iliac crest were palpated as reference points. To obtain a clear image of the three deep abdominal layers, ultrasound gel was interposed between the transducer and the skin, and the transducer was transversely located across the abdominal wall 25 mm antero-medial to the midway point between the 12th rib and the iliac crest over the anterior axillary line (14).

Subjects were asked to draw their navel up and in towards the spine without moving their upper abdomen or spine after a deep breath at the end of the exhale in order to perform the abdominal hollowing, which is a specific contraction of the TrA and IO muscles (15). A pressure biofeedback device was used to standardize the abdominal hollowing maneuver (15, 16). A Chattanooga pressure biofeedback device was placed under each patient's fifth lumbar vertebra to monitor lumbar movement when performing the abdominal manoeuvre. Inflatable pillow pressure biofeedback was initially set at 40 mmHg while the subject was at rest. The subject was then required to increase the pressure to 50 mmHg for the abdominal hollowing manoeuvre (15). The pointer of the biofeedback device was placed so that it could be seen by both examinee and examiner. As a result, the contractions could be controlled to a desirable intensity.

To perform PFM contractions, the instruction was given to draw in and lift the PFM (17). After being taught verbally, correct PFM contractions were assessed by observing the lifting of the bladder base on transabdominal ultrasonography (Ultrasonix-ES500, Burnaby, BC, Canada, 3.75-MHz curved linear-array transducer). Only contractions with simultaneous

Table 1. Demographic Data of Healthy and low back pain (LBP) Groups

Variables	Group	Min	Max	Mean ± SD
Age (y)	Healthy	18.0	32.0	23.9 ± 3.5
	LBP	18.0	42.0	25.8 ± 6.2
Weight (kg)	Healthy	50.0	76.0	57.2 ± 8.1
	LBP	49.0	82.0	62.0 ± 9.8
Height (cm)	Healthy	154.0	183.0	165.0 ± 9.0
	LBP	155.0	185.0	165.0 ± 7.8
Body-mass index (kg/m^2)	Healthy	18.6	23.4	20.8 ± 1.2
	LBP	16.6	28.0	22.0 ± 3.8

Table 2. Abdominal Muscles thickness (cm) During AHM Alone and with PFM for Healthy and LBP Groups

Muscle	Condition	Group	Mean ± SD
Transverse abdominis	AHM	Healthy	4.9±1.5
		LBP	5.4±1.9
	AHM+PFM	Healthy	5.3±1.4
		LBP	4.8±1.3
Internal oblique	AHM	Healthy	8.4±2.6
		LBP	8.5±1.9
	AHM+PFM	Healthy	8.4±2.6
		LBP	8.1±2.4
External oblique	AHM	Healthy	5.1±1.7
		LBP	5.8±1.5
	AHM+PFM	Healthy	5.2±2
		LBP	5.4±1.5

AHM: abdominal hollowing maneuver. PFM: pelvic-floor muscle. LBP: low back pain

Table 3. Results of Repeated Measure Test

source	Type 111 sum of squares	DF	Mean squares	F	Sig
Muscle	116.6	2	58.3	31.3	* *P*<0/001
Muscle*group	4.66	2	2.33	1.25	0.29
Condition	o.9	1	0.9	0.62	0.43
Condition* group	4.5	1	4.5	3.1	0.08
Condition* muscle	0.11	2	0.05	0.09	0.9
Condition* group*muscle	0.71	2	0.35	0.59	0.55

observation of upward movement of the bladder base were recorded as correct contractions. All contractions were held for 3 seconds with a rest of 5 seconds between them. Two images were obtained at each condition (hollowing maneuvers with and without PFM contraction). The order of contractions was randomly selected to minimize potential sequence effect.

Data analysis**:** Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS) 16 software. The Kolmogrov–Smirnov test was used to assess the normality of distribution for the tested variables. A two-way mixed-design analysis of variance (ANOVA) accounting for condition (abdominal maneuver without PFM vs. abdominal maneuver with PFM), health status (LBP vs. no LBP), and interaction of condition and health status effects was used to test the ultrasound measurement of the changes in thickness of each abdominal muscle (TrA, IO, and EO) in all subjects. Statistical significance was set at $P = 0.05$.

Results

The demographic data for the subjects in both groups are shown in Table 1. No differences were found in age or body-mass index between the two groups. Descriptive statistics (mean±standard deviation (SD), abdominal muscles thickness (IO, TA, and EO) during AHM with and without PFM for healthy and LBP subjects are shown in Table 2. Table 3 shows the results of the repeated measure test. The results showed no significant condition for muscle-interaction effect on abdominal muscles thickness during AHM (P=0.55)

Discussion

The results of the current study showed that there was no significant difference in the amount of changes in the thickness of abdominal muscles in contraction alone or in combination with PFM contraction during the hollowing maneuver in the two subject groups. This means that the addition of a PFM contraction has no significant effect on abdominal-muscle contractions.

This finding appears to be contradictory to those of previous studies that reported the involvement of the pelvic floor muscles in the activity of abdominal muscles and, in contrast, the pelvic floor muscles' contraction in response to the hollowing maneuver (10, 11, 14). Previous studies have been based on the idea of Richardson and Hodges who stated that the PFM act with abdominal and diaphragm muscles in dynamic stability control of the pelvic-lumbar spine and, in fact, consider the dynamic control of pelvic-lumbar spine muscles as owing to the harmonic cooperation of spine local muscles, PFM, and the diaphragm (7, 18-20). A closer review of studies in this area show that, according to researchers, PFM come into action with other abdominal muscles in functional activities such as sneezing, blowing, coughing, laughing, lifting heavy objects, performing the Valsalva maneuver (19), and other activities that increase intra-abdominal pressure to maintain and increase intra-abdominal pressure and thereby increase lumbar-pelvic stability. Whether this conclusion indicates that the results of this study reject those of previous studies remains a question.

This difference in findings may be due to differences in the type of co-activation pattern of abdominal and PFM contractions in previous studies compared with that of the current study. As mentioned in the literature review, the simultaneous contraction of these two muscle groups has been investigated differently in previous studies. For example, Sapsford et al. reported the contraction of the abdominal muscles in response to the contraction of pelvic floor muscles and, in contrast, the PFM contraction in response to the hollowing and bracing of the abdominal muscles (10, 11). Neumann and Gill (21). Investigated the counter-effect of abdominal and PFM contractions in a similar study and concluded that PFM activity increased during the testing of abdominal muscles in the supine position.

Another method for assessing the co-activation pattern of abdominal muscles and PFM, which can be seen in another group of studies, has to do with examining the simultaneous contraction of these two muscle groups in automatic activities, such as coughing or sneezing, or in functional activities like raising the head and shoulders. Peschers *et al.* (22) reported an increase in PFM activity during the Valsalva maneuver. Thompson *et al.* (23). observed the same phenomenon during the Valsalva maneuver in women with urinary incontinence. Neumann and Gill (21) reported an increase in the activity of the PFM associated with increased activity of the transverse abdominal and internal oblique muscles during coughing and pressured expiration. Smith et al.(24)observed simultaneous increases in the abdominal muscles and PFM activity following upper limb movements.

The findings of both studies were the EMG and ultrasound activity of another muscle group following intentional or reflex contraction of a muscle group, and this increase in the EMG and ultrasound activity is significant compared to the resting position.

In fact, the difference in the pattern of co-activation of abdominal muscles and PFM in this study, as compared to previous studies, is that PFM contraction in this study was performed when the abdominal muscles were contracted during hollowing or bracing maneuvers. In fact, the current study found that when abdominal muscles are active or increasing in thickness, the addition of PFM contraction to abdominal muscles' contraction causes no significant change in abdominal muscles' thickness, and this does not necessarily mean a rejection of previous studies. Rather, it can be due to differences in the method of assessing the synchronization pattern, as the recent study assessed the intentional contraction of muscles as recommended in exercise therapy and did not consider automatic activity of abdominal muscles. Bo *et al.* (12) also concluded in a study, which was probably similar to the current study, that adding an intentional contraction of the abdominal muscles to the PFM contraction does not cause significant changes in the ultrasound index and concluded explicitly against previous theories that the abdominal muscles are not required in the PFM contraction retraining program.

Conclusion

Prescribing an exercise protocol for LBP patients and healthy people concomitant with the contraction of PFM has no additional effect on the abdominal-muscle contraction.

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Conflict of interest:
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All authors made substantial contributions to conception, design, acquisition, analysis and interpretation of data.

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