

Electromyography Activity of the Abdominal Muscles Relative to the Active Pelvic Floor Muscle Contraction in Low Back Pain and Healthy Individuals

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Abstract

Introduction: The purpose of present study was to compare electromyography activity of the abdominal muscles in response to the active pelvic floor muscle contraction in individuals with and without low back pain (LBP). **Methods:** A total of 30 female subjects (LBP=15) and (healthy=15) participated in the study. All subjects performed the active PFM contraction for three times. The correct pelvic floor muscle contraction was controlled by an ultrasound. Simultaneously, the electromyography signals of the right transverse abdominis, internal oblique and external oblique muscles were measured. Variables of electromyography amplitude were analyzed using an independent sample T-Test. **Results:** There was a high intra-tester reliability for electromyography measurement of abdominal muscle in LBP (ICC>90) and healthy individuals (77<ICC<96). Transverse abdominis, internal oblique and external oblique muscle electromyography activity were increased during the pelvic floor muscle contractions in both women group with and without low back pain. The results of independent sample T-Test displayed no statistically significant difference in muscle co-activation pattern of the abdominal and pelvic floor muscles between the healthy group and LBP group ($P>0.05$). The mean values for muscle electromyography amplitude in transverse abdominis, internal oblique and external oblique muscle were 0.37(0.41), 0.18(0.14) and 0.16 (0.10), respectively, for healthy individuals and 0.25 (0.17), 0.13 (0.19) and 0.18 (0.17) for individuals with LBP. **Conclusion:** There is a recognizable co-activation between abdominal and pelvic floor muscles in healthy and low back pain women.

Keywords: Pelvic Floor Muscles, Abdominal Muscles, Low Back Pain, Electromyography

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Introduction

Low back pain (LBP) is one of the most common cause of inability to work in today's societies (1, 2). Based on the literature, 70-80% of the western population experienced at least one episode of LBP in their life time. In point of fact, this problem which has a high prevalence rate annually leads to higher payments from governments (3). There are several factors associating with the development of LBP. Based on the stabilizing system of the spine suggested by Panjabi (1992), however, much attention has been given to the concept of spinal stabilization. Indeed, spine stability requires appropriate participation of passive, active and neural control subsystems, and the impairment even in one component could affect integrity and stability of the spine which possibly causes the pain (4).

The deep antero-lateral abdominal muscles, Transvers Abdominis (TrA) and Internal oblique (IO), as an active component, play an important role in providing spinal stability during functional activities. The substantial evidence displayed deep local muscles dysfunctions in individuals with chronic LBP (5, 6). Pintoes *et al.* reported a significantly lesser increase in Transverses Abdominis (TrA) thickness with isometric leg tasks in people with LBP, compare to healthy group. Also, similar result was identified for muscle Electromyography (EMG) activity of TrA with leg tasks which was lesser in people with LBP. Moreover, no significance difference for EMG activity and muscle thickness of IO and External Oblique (EO) was described (7).

In recent decades, musculoskeletal physiotherapists paid more attention to pelvic floor muscle (PFM) complex as another



Figure 1. EMG electrodes placement



Figure 2. Ultrasound's probe placement

active concept of spinal stabilization in treating patients with low back pain. Some studies investigated the role of PFM in generating, maintaining and increasing intra-abdominal pressure for functional tasks such as lifting, laughing, coughing as well as Valsalva manoeuvre (8-10). In addition, dysfunction of PFM has been displayed for individuals with LBP in comparison with healthy subjects (11).

Several EMG studies investigated the co-activation pattern of the pelvic floor and the abdominal muscles (12-14). Some researchers have demonstrated the abdominal muscle contraction during active voluntary PFM contraction in healthy subjects and more increase in TrA and EO activation (15). In the other hand, increase in the vaginal EMG amplitude of PFM during different abdominal tasks indicated a synergy pattern of PFM and abdominal muscles (16, 17). Even though co-activation pattern of PFM and abdominal muscles have been investigated as a substantial clinical approach in recent investigations, to the best of our knowledge, there is no study on detection of the abdominal muscles response to active PFM activation in people with LBP, and the majority of studies have focused only on healthy populations or subjects with stress urinary incontinence (SUI) (18).

The purpose of this study was to determine the activation pattern of muscles as well as comparing the electrical muscle activation of the deep abdominal muscles during PFM contraction in subjects with and without LBP. Superficial EMG is a common conservative method to study muscle electrical activation. The validity and reliability of this method has been established in the literature (19, 20). These findings support the use of surface electromyography as a cost-effective, non-invasive and accessible technique to assess the abdominal muscle activation in addition to the muscle activation patterns.

Material and Methods

Subjects

Fifteen women with LBP and fifteen age-sexes matched without LBP (as a control group) were contributed in the present study. All participants had no history of pregnancy, abdominal or spinal surgery, severe trauma or spinal instability, and neurological or myopathy disorders. Subjects with the history of at least three episode of LBP which limited functional activity and last more than one week in the past 12 months and had an episode of LBP within the past 6 weeks were included as subjects with LBP (21). Individuals with LBP were referred by a physician. Healthy students of University of Welfare and Rehabilitation Science with no pain in their low back, pelvis, thoracic and lower extremities were considered as the control group. The mean age of participants in the LBP group and healthy group were 25.73 years (18-38) and 24.2 years (18 to 32), respectively.

It should be noted that the Intra-tester reliability of EMG measurement was assessed in another independent study. Actually, 21 volunteers were participated in reliability study (12 healthy subjects and 9 subjects with LBP) performed by just one examiner. The reliability study was designed exactly similar to the main study. All participants signed an informed consent form approved by the human subjects committee at the University of Social Welfare and Rehabilitation Science and filled out a simple health questionnaire before participating in the study.

Instrumentation

Surface EMG data from the abdominal muscles were obtained by bipolar pairs of Ag-Ag electrodes. Electrodes were placed on the right side along the line of the underlying muscle fibre action (Figure 1): TrA (2 cm cephalad to the pubic bone just lateral to midline and parallel to the superior pubic ramus), EO

Table 1. Intra-Tester reliability data

Variables	With LBP		With no LBP	
	ICC	SEM	ICC	SEM
Transversus	0.96	0.05	0.91	0.04
Int-Oblique	0.77	0.04	0.91	0.01
Ext-Oblique	0.84	0.13	0.89	0.02

(over tip of eighth rib), and IO (2 cm proximal to the midpoint of a line from the anterior superior iliac spine to the symphysis pubis) (10). A common reference electrode was located for each pair of electrodes (Figure 1). All surface EMG data were sampled with a Bortec AMT-8 amplifier system (band pass 10 Hz–1 kHz, CMRR 115 dB at 60 Hz, input impedance 1 GX, gain 1000). Data were acquired at 1000 Hz frequency and were analyzed using the Myodat software.

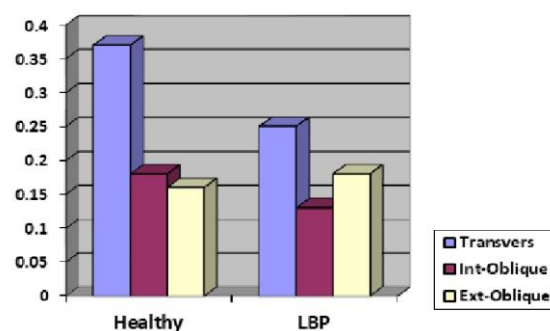
For monitoring pelvic tilt during PFM contraction, a biofeedback pressure was placed in subjects' lumbar lordosis (22). Participants didn't need to perform posterior pelvic tilt during PFM contraction. In order to proper the PFM contraction, the examiner controlled any pressure changes in the biofeedback pressure that means incorrect contraction.

In additional, a diagnostic ultrasound imaging unit set in B-mode (Ultrasonix-ES500, Canada) with a 3.75 MHz curved (convex) array transducer was used to observe the bladder neck displacement during the correct PFM contraction. The ultrasound transducer was located transversely in the midline on the suprapubic region and angled in a posterior/caudal direction (Figure 2). In order to detect the clearest image of the bladder space in each participant, the angle of the transducer was adjusted (23).

The subjects were assessed in the crook lying position (supine with both hips and knees flexed to 60 degrees) with a pillow under knees. The surface of their skin was shaved and then cleaned with alcohol wipes before the EMG electrode placement. Participants were trained by a physical therapist to perform the correct PFM contraction. A proper maximal PFM contraction was achieved when the lifting of the bladder base observed on trans-abdominal ultrasound imagine. Participants performed three maximum PFM contractions and hold each contraction for 4 seconds with at least 5 seconds rest between each repetition. In order to complete the reliability test, tests were performed two times for every subject with at least a 30-minute interval rest. Reliability study data collection were also carried out during one day. Muscles EMG data were normalized to submaximum EMG amplitude of these muscles during their voluntary isometric contraction.

Data analysis

Kolmogrov-Smirnov test was used to determine the normal distribution of all tested variables. The intra-class correlation

**Chart 1.** Abdominal muscles electromyography activity in healthy and LBP women

coefficient (ICC) and standard error of measurement (SEM) were utilized to assess intra-tester reliability of the measurements.

Independent sample T-Test was used to compare EMG activity of abdominal muscles in response to PFM contraction between healthy group and LBP group.

Results

Results showed the high intra-tester reliability for abdominal muscle measurements' in LBP ($0.77 < ICC < 0.96$) and healthy individuals ($0.89 < ICC < 0.91$). The demographic data for reliability study is shown in Table 1. Descriptive statistical data for the subject variables in main study, (mean $\pm$ SD) for abdominal EMG activity, and maximum amplitude of abdominal muscle activity during PFM contraction is shown in Table 2, Table 3, and Chart 1, respectively.

The result of independent sample T-Test and the descriptive statistics (Table 3) showed no significant differences in abdominal muscles activity pattern in healthy group compared with the group with LBP.

Discussion

Current study presented a high reliability of surface EMG for abdominal muscle activity during the PFM contraction. Previous studies stated that muscle EMG is considered as a reliable measurement for abdominal muscle activity (19, 20, 22).

We detected the electrically activation of TrA, IO and EO muscles during PFM contraction in both women groups with and without LBP, which showed co-activation between PFM and abdominal muscles. These findings confirm the data from previous EMG studies which demonstrated a synergistic relationship between PFM and abdominal muscles in healthy subjects (12-15). Other studies established abdominal muscles thickness changes in response to PFM contraction in healthy and urinary stress incontinent women with using ultrasound imaging (16, 17).

Table 2. Variables descriptive Statistical data

Variables	LBP			Healthy		
	Max	Min	Mean (SD)	Max	Min	Mean (SD)
Age(Year)	38	18	25.73(6.27)	32	18	24.2(3.49)
Weight(Kg)	80	49	62.07(9.67)	76	50	57.13(8.18)
Height(Cm)	185	155	168(8.1)	183	152	165(9.48)
BMI(Kg/CM2)	25.04	17.5	20.78(3.82)	23.34	18.65	20.81(1.27)

Table3. Independent sample T-Test result of abdominal muscles in healthy and LBP women

Variables	LBP	Healthy	P-value	t
	Mean (SD)	Mean (SD)		
Transversuse	0.25 (0.17)	0.37 (0.41)	0.29	1.08
Int-Oblique	0.13 (0.19)	0.18(0.14)	0.31	1.42
Ext-Oblique	0.18 (0.17)	0.16(0.10)	0.61	0.51

In trunk muscles, the TrA and posterior fibers of the IO muscle are known as a local and primary spinal stabilizer, and EO is known as a global muscle (10, 12). In present study, the enhancement of EMG activity was considerably more in TrA as a deep abdominal muscle in both healthy and LBP groups. Actually, there was an increase in EMG activity of local muscles (TrA and IO) and simultaneously a decrease in global muscle activity (EO) in women with LBP. Difference between amplitude of muscles EMG activity in woman with and without LBP was not statistically significant. Richardson *et al.* demonstrated the reduction and enhancement of muscle EMG activity in local and global muscles of people with LBP, respectively (24) which is in disagreement with the present study.

The co-activation pattern identified between PFM and abdominal muscles in subjects with LBP indicates an undeniable role of PFM in intra-abdominal pressure development thereby providing the lumbar pelvic stability. By considering the clinical aspect, it should be noted that muscle co-contraction pattern between PFM and abdominal muscles could be considered as reflecting the significance of PFM exercise in individuals with LBP. Indeed, emphasizing on PFM training could cause the intra-abdominal pressure improvement which lead to stimulation of abdominal muscle activation, especially in TrA muscle.

In present study we faced with some limitations that could affect our results, such as the quantity and condition of the pain in participants with LBP. Some individuals with LBP were excluded in order to have more homogenous population if they experienced pain more than 3 during the test according to the Visual Analog Scale (VAS). Given that muscle EMG just reflects electrical muscles activity, assessing mechanical muscle activity and muscle thickness by sonography in individuals with LBP could be desirable for future works.

Conclusion

Present study considered the EMG activity enhancement of abdominal muscles (TrA, IO, EO) during PFM contraction in both groups of women with and without LPP. Our finding indicated no statistically significant differences in the EMG activity of abdominal muscles during PFM contraction between women with and without LBP. This study proposes the existence of PFM and abdominal muscles co-activation in women with LBP.

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Conflict of interest:

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All authors made substantial contributions to the conception, design, analysis, and interpretation of data.

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