Evaluation of pelvic floor muscles activity with and without abdominal maneuvers in subjects with and without low back pain

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Evaluation of pelvic floor muscles activity with and without abdominal maneuvers in subjects with and without low back pain

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Abstract.

BACKGROUND: There was controversy in finding of studies related pelvic floor muscle (PFM) rehabilitation of subjects with low back pain (LBP), while this issue is very important for treatment of subjects with LBP.

OBJECTIVE: The purpose of this study was to evaluate PFM contraction in three conditions of alone and with abdominal hollowing (AH) or abdominal bracing (AB) maneuvers in subjects with and without chronic LBP.

METHODS: Subjects were divided into two groups: subjects with LBP (N = 25) and without LBP (N = 27). PFM contraction alone and during contraction with AH or AB maneuvers was measured. The amount of bladder base movement was measured as an indicator of PFM activity.

RESULTS: There were no differences in PFM activity between subjects with and without chronic LBP, when PFM contracted alone (P = 0.60), contracted with AH (P = 0.12) and AB maneuver (P = 0.54). Our data revealed that contraction of the PFM alone produce greater displacement of the bladder base than contraction of the PFM with AH (P = 0.005) or AB maneuver (P = 0.001) in both groups. However, no significant difference was found between contraction of the PFM with AH and AB maneuver in individuals with LBP (P = 0.31).

CONCLUSION: It seems that PFM contraction alone is more effective than PFM contraction with AH or AB maneuvers in lifting the pelvic floor in subjects with and without LBP.

Keywords: Abdominal muscles contraction, low back pain, pelvic floor muscles, ultrasound

1. Introduction

Low back pain (LBP) is one of the most common musculoskeletal complaints and costly health problems in today’s societies.\[1\] Around 70–80% of people...
ple eventually experience this problem at least once in their lifetime [2]. It seems that LBP is a complex and multi-factor disorder with unclear definitive anatomical causes or initiating factors [3]. Patients suffering from chronic or recurrent LBP have been reported to alter their motor control strategies [4] and lumbo-pelvic stability [5]. At the same time, there is considerable evidence that pelvic floor muscles (PFM) is associated with other deep stabilizing muscles such as deep abdominals and multifidus which provide the stability of the lumbo-pelvic region [6–8].

Some studies have shown that control of increased intra-abdominal pressure is performed automatically as a feed-forward loop via the recruitment of the deep abdominal muscles, together with the PFM and diaphragm [9]. PFM dysfunction may cause impaired load transfer and pain in the lumbo-pelvic area that lead to develop LBP [10,11]. Numerous investigators have demonstrated a link between LBP and genito-urinary dysfunction such as urinary incontinency [11,12]. However other studies have reported that the PFM dysfunction also contributes to urological dysfunctions such as incontinency [13,14].

Because of the use of different testing designs, procedures and samples, studies regarding PFM dysfunction in LBP patients have resulted in controversial results. Some previous studies have been demonstrated a decrease in the PFM endurance times in patients with pregnancy-related LBP compared to healthy participants [11] or altered motor control of PFM in individuals with sacroiliac joint pain [10]. Using ultrasound, Arab et al. (2010) found that patients with chronic LBP also experienced PFM dysfunction unlike those without LBP [15]. In contrast, Stuge et al. (2006) found no significant difference in the PFM strength between women with and without long lasting pelvic girdle pain [16].

Other literatures in this field have shown that the pelvic floor and deep abdominal muscles are activated at the same time to increase the intra-abdominal pressure and fascia tension and thus transfer the load [6,9]. Thus the PFM are generally accepted as a part of the trunk stability mechanism. According to these findings, it seems that PFM assessment, re-education and rehabilitation is an important method and an effective means of correcting the altered trunk muscle recruitment pattern in LBP patients.

Different methods have been applied for PFM training. Some investigators have demonstrated that the co-contraction of the abdominal muscles could facilitate the PFM contraction and recommend indirect training of the PFM through abdominal muscles for instruction and re-education [7–17]. While other studies have reported that considering the effects of the abdominal muscle contraction on the intra-abdominal pressure and thus descending of the levator plate [18] can weaken the PFM even more in the long term [19]. Therefore, it has been recommended that PFM contraction alone might be more effective when rehabilitating the PFM compared to abdominal muscles co-contraction [19,20]. This controversy may be due to the different types of abdominal muscle contraction used in different studies or the included samples.

The abdominal hollowing (AH) and abdominal bracing (AB) maneuvers are commonly used to activate and rehabilitate abdominal muscles. The AH maneuver is performed to activate deep abdominal muscles and involves gently drawing the lower abdominal wall in toward the spine without moving spine or pelvis [21,22]. The emphasis of the AB maneuver is on the activation of all the abdominal wall muscles that create stiffness in the spinal column [22]. This is achieved by instructing the participants to tighten their abdominal wall and increase the lateral diameter of their waist [22,23].

Real-time ultrasound imaging is a reliable and valid method and has been recently used to evaluate muscle structure, size, motion and activity [24]. Recently, an interest in the use of trans-abdominal (TA) ultrasound to evaluate PFM contraction has developed. This method has been established as a completely safe, non-invasive, reliable and comfortable technique for participants [13]. In this imaging method, the amount of movement of the bladder based on the TA ultrasound is considered as an indicator of the PFM mobility during muscle contraction [13,14,19].

To our knowledge, no study has directly evaluated the PFM function with abdominal muscles’ co-contraction during different maneuvers in participants with and without chronic LBP by measuring the TA ultrasound. The aim of this study is to evaluate the PFM function using TA ultrasound in participants with and without chronic LBP and in the following three conditions of exercise: 1) simple PFM contraction, 2) PFM contraction with AH maneuver and 3) PFM contraction with AB maneuver. We hypothesized that PFM contraction alone created a larger bladder base displacement compared to the PFM contraction with abdominal maneuvers in patients with LBP.
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Table 1

<table>
<thead>
<tr>
<th>Demographic data of the participants in both groups (Mean ± D)</th>
<th>No LBP (N = 27)</th>
<th>LBP (N = 25)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>33.94 ± 8.97</td>
<td>40.76 ± 1.79</td>
<td>0.015</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>64.35 ± 1.35</td>
<td>71.80 ± 4.95</td>
<td>0.018</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>163.73 ± 8.78</td>
<td>165.76 ± 9.76</td>
<td>0.360</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>23.98 ± 3.57</td>
<td>25.93 ± 3.29</td>
<td>0.025</td>
</tr>
<tr>
<td>Gender (male/female)</td>
<td>11/16</td>
<td>10/15</td>
<td>0.330</td>
</tr>
</tbody>
</table>

BMI = Body Mass Index.

2. Materials and methods

The study design was a two-factor mixed design to compare the PFM function for the three conditions and two groups with and without chronic LBP.

Participants were classified into two groups: participants with chronic LBP (N = 25) and those without chronic LBP (N = 27). This sample size presented 80% power to detect the PFM function for the three conditions and two groups with 95% CI.

Individuals were included if they gave their consent to participate in the study. Participants with chronic LBP were selected from the individuals seen in the orthopedic and physical therapy departments. All individuals participating in the study filled out a simple health questionnaire. Those who met the selection criteria were included in the study. The participants signed an informed consent form approved by the human participants’ ethics committee at the University of Social Welfare and Rehabilitation Sciences before participating in the study.

The control group participants in a one hour period, half an hour prior to the test. The participants were evaluated in a crook-lying position. 600–750 ml of water was consumed by the participants in each group is shown in Table 1.

Patients were included if they had a history of LBP for more than six weeks before 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 before the study [25]. The control group were evaluated and found to have no complaints of any pain or dysfunction in their low back, pelvis, thoracic and lower extremities. Participants were excluded if they had any history of spinal surgery, spinal or pelvic fracture and hospitalization for severe trauma or car accident, urinary tract infection, vaginal infection and known neurological disorders. The patients who experienced pain during the testing procedure also were excluded from the study.

A pressure biofeedback device was used to indirectly measure the pressure exerted by the abdominal muscles and to standardize each abdominal maneuver [22]. This is a reliable method that is used to measure the abdominal muscle pressure [26]. The pressure biofeedback device was placed under the lumbar area (centered about L3), when the participant was in rest, supine crook lying position. It was initially set at 40 mmHg and the participant was asked not to increase the pressure more than 50 mmHg during both abdominal maneuvers [22]. The PFM contraction was evaluated using a TA ultrasound device in three conditions: 1) simple PFM contraction, 2) PFM contraction with AH maneuver and 3) PFM contraction with AB maneuver.

The AH maneuver was performed to activate deep abdominal muscles (Transverse abdominis (TrA) and obliquus internus (OI)) [21]. This maneuver involves drawing the lower abdominal wall in towards the spine [21][22]. The AB maneuver was performed with emphasis on the activation of the obliquus externus in addition to the TrA and OI. This was achieved by instructing the participants to tighten their abdominal wall and increase the lateral diameter of their waist [22][23].

Trans-abdominal ultrasound measurement: the pelvic floor elevation was measured using diagnostic ultrasound imaging unit set in the B-mode (Ultrasonix ES500, Canada) with a 3.5 MHz curved array transducer. Ultrasound measured the amount of the bladder base movement as an indicator of the PFM contraction [13][14][19]. The transducer was placed suprapubically, on the lower abdomen, in the transverse plane and angled in a caudal/posterior direction at about 15–30 degrees from the vertical direction to obtain a clear image of the inferior-posterior aspect of the bladder. To provide clear images of the bladder base, a standardized bladder filling protocol was used prior to imaging. 600–750 ml of water was consumed by the participants in a one hour period, half an hour prior to the test. The participants were evaluated in a crook-lying supine position with one pillow underneath their head and the hips and knees flexed to approximately 60 degrees with the lumbar spine positioned in an approximately neutral position. At the rest position, during the test, a marker was first placed on the screen at the clearly defined edge of the bladder base, in the region of the greatest displacement during the PFM contraction. The participants were asked to perform maximal PFM contraction in the three conditions. First, in the instruction, participants were learned to tighten their PFM correctly, like when they try to stop the flow of urine, for several times. Then, progressive instructions with ultrasound biofeedback were given to participants to appropriately hold maximal PFM contraction alone, with AH and AB maneuvers for three seconds. Uni
All the participants could not learn completely the instructions, they were not included in the study. The amount of the bladder base displacement from the resting position to the end of each contraction was measured in millimeters (mm). The reliability of the trans-abdominal ultrasound measurement of the PFM contraction has previously been established [13,27].

All measurements were performed by the same examiner. The examiner was blind with regard to the subject grouping for the PFM contraction measurements. The order of the maneuvers was randomized in every participant. First, each maneuver was given a number code. Then, each participant took a number code that was written on a separate card. Accordingly, each maneuver was selected randomly for every participant.

Three repetitions of each maneuver were performed with a 10 second rest period between each repetition and one minute rest between each maneuver. The mean value of the three contractions was given for analysis.

A two-way mixed-design ANOVA, accounting for the health status (chronic LBP vs. no chronic LBP), maneuvers (PFM vs. PFM with AH vs. PFM with AB) and interaction of maneuvers and health status effects was applied to test the difference in the PFM contraction during different conditions between the two groups. The independent t-test was applied to evaluate the differences between the two groups in variables of age, body mass index (BMI), weight and height.

Because of the effect of BMI and body size on muscle function and strength [13]; in this study, the calculated trans-abdominal ultrasound measurement of the PFM contraction was normalized to their calculated BMI. The normalized data was used in the analysis.

3. Results

The sample demographic data collected from with and without LBP subjects are summarized in Table 1. There was no statistically significant difference in height ($P = 0.36$), gender ($P = 0.31$), and significant difference in age ($P = 0.015$), weight ($P = 0.018$) and BMI ($P = 0.025$) between groups. Figure 1 depicts the average normalized ultrasound measurement scores for PFM contraction in the three conditions and for the two groups. Descriptive statistics (Mean ± D) has been provided in Table 2.

The result of two-way mixed-design ANOVA showed no significant health status by maneuver interaction effect for PFM contraction ($P = 0.41$). While the effect of maneuvers ($p < 0.0001$) on the PFM function was statistically significant in both groups, this meaningful effect was not visible in participants with and without LBP ($p = 0.28$).

There were no significant differences in TA ultrasound measurements of the bladder base displacement between participants with and without chronic LBP during the simple PFM contraction ($P = 0.60$), the PFM contraction with AH maneuver ($P = 0.12$) or the PFM contraction with AB maneuver ($P = 0.54$) (Table 2).

In participants with no chronic LBP, our data revealed that PFM contraction alone produce significantly greater displacement (in the cranio-ventral direction) than contraction of the PFM with AH ($p < 0.0001$) or AB ($p < 0.0001$). However, PFM contraction with AH produced significantly greater displacement than contraction of the PFM with AB ($p < 0.0001$).

In participants with LBP, the contraction of the simple PFM produced significantly greater cranioventral displacement than the contraction of the PFM with AH ($P = 0.005$) or AB ($p = 0.001$). However, there was no significant difference between the contraction of the PFM with AH and AB ($p = 0.31$).

4. Discussion

We hypothesized that bladder base in the condition of PFM contraction alone was displaced more than condition of PFM contraction with abdominal maneuvers in the patients with LBP. The result of present study supports this hypothesis. The results of
the present study demonstrated that PFM contraction alone was significantly more effective compared to the co-contraction of the PFM and abdominal muscle (AH or AB maneuvers) in individuals with and without chronic LBP using ultrasound. However, participants with no chronic LBP, although statistically not very significant, produced more bladder base elevation compared to participants with chronic LBP during the three testing conditions. The PFM contraction with the AH maneuver was significantly more effective in elevating the bladder base compared to the PFM with AB maneuver in healthy participants, whereas participants with chronic LBP demonstrated no significant difference in the bladder base elevation between the PFM contraction with AH and AB maneuvers.

The finding of this study confirms result of some studies. Bo et al. (2003, 2009) demonstrated that the instruction and re-education of PFM alone was significantly more effective than the PFM contraction with AH maneuver [19,20]. However, similar findings have been reported by Bo et al. (2003) in which researchers used ultrasound to measure the PFM contraction [19]. Hay-Smith et al. (2001) have also shown that PFM contraction alone effectively improved the PFM strength and the stress urinary incontinency [28], while some electromyographic (EMG) studies have indicated the co-contraction of the PFM and abdominal muscles during voluntary maneuvers in healthy participants [6,8,23]. Madill and McLean [17] also demonstrated the increase in intra-vaginal pressure during the voluntary PFM contraction and co-activation of pelvic floor and abdominal muscles instead of PFM alone. Our findings do not confirm the result of the study conducted by Sapsford et al. (2001; a, b) which showed more EMG activation of the PFM in strong abdominal muscles contraction in different positions [6,23]. This conflicting result may be due to the difference in measurement methods (EMG vs. ultrasound) and testing procedure that causes the indirect comparison of the studies’ results. While they recorded automatic activation of the PFM during abdominal muscles contraction in healthy participants, in this study, the voluntary PFM contraction with and without abdominal maneuvers was compared in participants with and without chronic LBP using ultrasound. However, the trans-abdominal ultrasound method used in this study has been shown to have a high reliability [13,27].

The present study demonstrated that although no significant difference was found in the TA ultrasound measurements of the PFM activity between participants with and without LBP during PFM contraction alone ($P = 0.60$), PFM with AH maneuver ($P = 0.12$) or PFM with AB maneuver ($P = 0.54$). Our data revealed that between group difference was greater during the PFM contraction with AH (0.10) compared to simple PFM contraction or PFM with the AB maneuver. Although in healthy participants, the PFM with AH was significantly more effective in elevating the bladder base compared to the PFM contraction with AB, participants with chronic LBP demonstrated no significant difference in this regard between the PFM contraction with the AH maneuver and the PFM contraction with the AB maneuver. This may be due to the poor functioning of the TrA muscle in subjects with chronic LBP. There is substantial evidence showing primary muscular impairment and the altered motor control strategy of deep local muscles such as the TrA in patients with chronic LBP [29]. It is possible that the alteration in the pattern of abdominal muscles recruitment visible in chronic LBP patients causes them to not coordinate effectively together with the PFM activity [4,15,20].

The fact that no significant difference was found between the two groups in the PFM activity with and without abdominal muscles contraction might be attributed to various factors such as the selection criteria, pain intensity, and the participants’ lifestyle. In this study, the patients who experienced pain during the testing procedure were excluded from the study as pain would have acted as a limiting factor for the contr.
pect contraction of the muscles. It is believed that pain during testing could inhibit the normal performance of the abdominal muscles or PFM during the contraction. More exclusive research is required to describe the effects of performing abdominal muscles contraction on the PFM activity in chronic LBP patients with different pain intensities.

The results of this study are in accordance with the work of Tahan et al. (2013) which showed no difference in the EMG activity of the abdominal muscles during the AH or AB maneuvers with and without PFM contraction in subjects with and without LBP [30]. The result of our study demonstrated that no difference exists in the voluntary activity of the PFM contraction with and without the abdominal muscles during the AH or AB maneuvers using ultrasound in subjects with and without LBP. Therefore, although there was a co-contraction of the PFM during the AH or AB abdominal maneuvers [9,17], the simple PFM contraction could create a larger bladder base displacement compared to the PFM contraction with abdominal maneuvers which resulted in a more appropriate training in the PFM [19]. This issue is very important in the rehabilitation of the chronic LBP.

On the otherwise, the finding of our study discriminated that although PFM alone was significantly more effective than the PFM contraction with AH or AB for rehabilitation and re-education purposes; the PFM activated more significantly in AH maneuver compared to the AB maneuver in healthy participants that were consistent with Hodges et al. studies [9,17]. In healthy people, the control of increased intra-abdominal pressure is performed automatically as a feed-forward loop via the recruitment of the deep abdominal muscles, together with the PFM and the diaphragm [9].

The findings of this study demonstrate that PFM contraction alone is significantly more effective compared to PFM contraction with abdominal muscle contraction (AH or AB maneuvers) in individuals with and without chronic LBP. However, participants with no chronic LBP, although not statistically significant, produced more bladder base elevation in comparison to participants with chronic LBP during the three testing conditions. Therefore, adding abdominal muscle training at the initiation of the rehabilitation program in the treatment of chronic LBP is not recommended for PFM re-education and rehabilitation.

However, we acknowledge some limitations. One of the limitations of this study was that the amount of increase in the intra-abdominal pressure during the abdominal maneuvers was not directly measured. A pressure biofeedback was used to standardize the abdominal maneuvers. Another area of concern in this study was that the voluntary PFM contraction was assessed alone or with abdominal maneuvers. It is suggested to investigate the automatic activation of the PFM contraction when performing abdominal maneuvers. Further research would be required to evaluate the use of another ultrasound unit at the lateral abdominal wall to simultaneously visualize the abdominal muscle’s contraction during the AH and AB maneuvers.

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References


