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Correlation between Upper and Lower Diaphragms in Patients with Low Back Pain associated with Urinary Incontinence

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Abstract

Background: Low back pain is commonly associated with urinary incontinence in females. This study aimed to investigate the relationship between pelvic floor muscles and diaphragm in females with low back pain associated with urinary incontinence.

Materials and methods: Twenty-five women with urinary incontinence and 25 women without urinary incontinence (control group) were included in this study. Their ages ranged between 35 and 45 years, with body mass index between 25 and 30 kg/m2, with a number of parities less than three normal vaginal deliveries. Patients were included if their last delivery was at least two years ago from the starting date of the study. Pelvic floor muscles and diaphragm excursion were evaluated using ultrasonography. Urinary distress inventory-6 (UDI-6) and visual analog scale (VAS) were also measured.

Results: Pelvic floor muscle strength and diaphragm excursion decreased in the incontinence group compared to the control group ($P < 0.001$). A correlation was found between the diaphragm excursion and Pelvic floor muscle strength ($r = 0.64$, $P = 0.001$).

Conclusion: There was a significant reduction in the diaphragm and Pelvic floor muscle activities in women with low back pain associated with urinary incontinence compared to normal individuals. Pelvic floor muscle strength and diaphragm excursion in females should be considered in with low back pain associated with urinary incontinence and which help therapists with therapeutic decisions.

Keywords: Low back pain, PFM, Diaphragm, urinary incontinence

Introduction:

The abdominal cavity is the body's largest hollow chamber. Its upper boundary is the diaphragm, and its lower boundary is the pelvic floor muscles (PFM). PFM works in collaboration with other muscles surrounding the abdominal cavity, particularly the anterolateral abdominal muscles and diaphragm, to modulate and respond to changes in intraabdominal pressure (IAP) and to provide trunk stability [1-2]. Urinary incontinence (UI) is termed, according to the International Association of Urinary Incontinence, as an involuntary leakage of urine [3]. It has a negative impact on multiple aspects of a woman's daily life, which may lead to social and hygiene issues [4].

The prevalence of UI rises with age, from 20%–30% for young adults to 30%–40% for middle-aged persons [5].

Age, pregnancy, childbirth, pelvic surgery, lower urinary tract infections, and various conditions that raise IAP, such as obesity, constipation, physical activity, and a long-term cough caused by smoking, are all traditional risk factors for UI [6]. Although no single etiology entirely explains the cause of UI, the pelvic floor issue, specifically the levator ani muscles, is the focus [5]. It is recognized as the most important factor in UI, in addition to continence maintenance and support of the abdominopelvic organs [7-8].

Low back pain (LBP) is a complicated illness that can be influenced by various personal, psychological, and occupational factors [9–11]. The reported point prevalence ranged from 12% to 30% in Western countries, and the reported lifetime prevalence ranged from 49% to 70%. Non-specific LBP affects over 90% of all LBP patients [12].

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It is essentially a diagnosis based on the exclusion of a specific pathology. A comprehensive review of prospective cohort studies showed that somatization, depression, and distress are linked to a higher chance of developing chronic LBP [9, 11, 13].

Evidence connects UI to musculoskeletal disorders such as LBP, pelvic discomfort, sacroiliac dysfunction, defecation issues, pelvic organ prolapse (POP), and sexual dysfunction [14–17]. Eisenstein et al., 2008 investigated the possible link between LBP and UI, highlighting the importance of detecting this link [16]. According to Eliasson et al.,2008 78% of women with LBP had UI [17]. According to Bush et al.,2013 women with persistent back discomfort had a higher incidence of stress urine incontinence (SUI) [18]. Furthermore, any pelvic and lumbar misalignment results in insufficient PFM activity and force distribution in these regions, which may be linked to UI [19, 20]. Pelvic floor muscles (PFM) work in synergy with other muscles surrounding the abdominal cavity, particularly the anterolateral abdominal muscles and diaphragm. Diaphragmatic movements modulate pressure distribution within the thoracic and abdominal cavities and influence the anterolateral abdominal muscles and PFM [28] [29]. The PFM relaxes during inspiration but also contracts to protect internal organs when the IAP increases. The PFM also contracts during a strong expiration period [30]. Moreover, the PFMs and diaphragm play important roles in motor control, contributing to the lumbopelvic region's dynamic stability [31]. These studies noticed that there is delayed activation of PFMs when lumbopelvic dysfunction is linked with UI [31, 32]. Thus the aim of this study was to assess the relationship between PFMs and diaphragm in women with LBP associated with UI.

2. Materials and methods

2.1 Study Design

The study was designed as an observational, cross-section study. Ethical approval was obtained from the institutional review board. The study followed the Guidelines of the Declaration of Helsinki on the conduct of human research. Each patient signed a written consent form after being given a thorough trial description. It was conducted between January 2023 and March 2023.

2.2 Participants

Based on gynecologist and orthopedist diagnosis and referral, 25 females with low back pain were recruited from the women's health outpatient clinic. Twenty-five females with mild to moderate UI in group A and 25 matched female control in group B.

2.3 Inclusion Criteria:

Group A included females patients diagnosed with non- specific LBP and diagnosed with mild to moderate SUI as well for at least 6 months based on gynecologist and orthopedist diagnoses andreferrals, with their ages ranging between 30 and 40 years, BMI ranging between 25 and 30 kg/m^2, they had three normal deliveries with the last one two years ago, and they had regular menstruation. Group B included 25 healthy females. None of the individuals had a history of musculoskeletal diseases, smoking, congenital disorders in the thoracic cavity, or PFM dysfunction.

2.4Exclusion Criteria

Any female with a history of disc prolapse, sacroiliac joint dysfunction, symphysis pubic joint dysfunction, lower limb dysfunction, severe UI, lower urinary tractsymptoms or genital prolapse were excluded from this study. Females with neurological disorders, diabetes mellitus, smoking, or cognitive deficiency were also excluded as well. Moreover, Females with diastasis of the recti, diabetes mellitus, intrauterine devices, surgery related to the spine, abdomen, or pelvis, and use of any medicinesfor pain or UI were excluded as well.

3. Evaluation methods

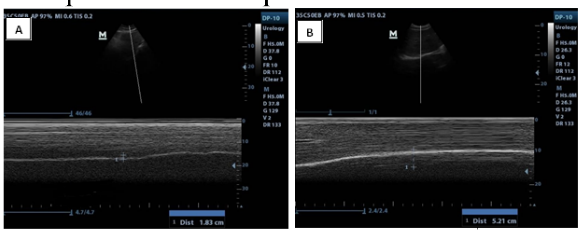
3.1 The Visual analogue scale (VAS). It was used to assess pain intensity for patients in group A. It is a useful tool for evaluating chronic pain. Patients with moderate pain got a score between 4 and 7 [35].

3.2 The urine Distress Inventory, Short Form (UDI-6) for group A, was used to assess the presence of UI and the frequency and amount of urine loss reported by the participants. This method was capable of measuring UI and its impacts without the use of expensive or time-consuming methods. It is a system for categorizing incontinence that is standardized. It consists of six components: frequent urination, leaking associated with a sense of urgency, leakage associated with exercise, coughing or sneezing tiny quantities of leakage (drops), difficulties emptying the bladder, and pain or discomfort in the lower abdominal or genital area. The total score ranged between 0 and 100. The greater the disability, the higher the UDI-6 scores [36].

3.3 Ultrasound imaging (Mindary DP10, curvilinear probe, 2.5-5 MHZ, China) was held to be a legitimate method for evaluating muscle recruitment. The main benefit of ultrasound imaging is how little invasive it is to evaluate soft tissue shape and muscle function during movement or while carrying out specified tasks **[37].**

3.3.a Assessment of PFM Strength

The force (strength) of voluntary PFM contractions was measured using ultrasound imaging in both groups. The measurements were done with the participant in a crock position and a full bladder



US Fig (1): measurement of PFM force (A) incontinence group (B) control group

The ultrasound probe was placed transversel to the midline of the participant's abdomen, above the symphysis pubis [38]. Participants were instructed to perform 3 maximal PFM contractions to evaluate the posterior bladder wall displacement during PFM contraction. Further, a clearly defined edge was selected for the measurement at the point with the greatest displacement observed during the movement. The image was taken at the point of maximum displacement. Further, the investigator measured the displacement to its current position. In addition, the examiner was blind to the measurement value until after the caliper was fixed. The probe was not moved during the procedure to ensure the field of vision remained constant between rest and maximal contraction. The mean of the three measurement was used for the statistical analysis **[39]**. Further, It has good inter- and intra- rater reliability for measuring PFM force (fig 1) **[40].**

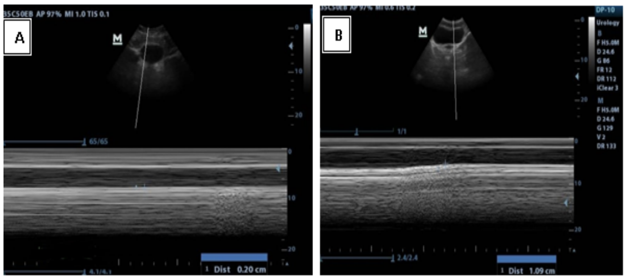


Fig (2): US measurement of diaphragmatic excursion (A) incontinence group (B) control group

3.3.b Assessment of Diaphragmatic Excursion

M-mode US imaging was carried out in the supine position to assess diaphragmatic excursion. The probe was positioned below the right costal border, between the mid-clavicular and anterior axillary lines, and was directed medially, cephalically, and dorsally to pick up the posterior section of the right hemi diaphragm. Calipers were placed at the bottom and top of the diaphragmatic inspiratory slope to measure diaphragmatic excursion; all measurements were recorded at the end of the expiration phase. [41].Diaphragmatic excursion US has a high temporal resolution, reproducibility, and accuracy, ICCs ranging between 0.876 and 0.999 for intraobserver agreement and 0.76 to 0.989 for interobserver agreement (fig 2) [42].

4. Sample size calculation and Statistical analysis:

Our sample size was estimated using an online epi tools program for **"Cross-sectional studies".**

Using the following parameters:

1-Prevalence ratio of urinary incontinence among middle-aged Egyptian Females **(35%)** [33], Confidence interval: **95 %**, Desired power: **80%**, Odds ratio: **53.31** [34]

The minimal required sample size was **(50).** Our study included two groups, each group (25) cases.

Statistics were carried out using SPSS version 22. Data variables were normally distributed. Quantitative data were presented as mean and standard deviation. Independent sample t–test was used to compare means. The correlation was done using Pearson correlation.

Table1: Comparison of diaphragm excursion and PFM force between group A and B:

	Group A (mean ± SD)	Group B (mean ± SD)	Mean difference (95% CI)	p value
Diaphragm excursion	**2.74±0.65**	**5.39±0.44**	**2.65- (-2.96-2.33)**	**P=0.001***
PFM force	**0.27±0.16**	**0.67±0.3**	**0.41-(-0.55-0.27)**	**P=0.001***

Table 2: Correlation between Diaphragm and pelvic floor muscles

	Pelvic floor muscles	
Diaphragm score	**R**	**P value**
	0.64	0.001*

5. Results

Participant characteristics:

The mean age of the group (A, B) were 38.13±3.94& 28.79±0.84, and BMI 37.33±5.49 & 29.22±0.37 respectively. There was no significant difference between the two groups in term of age and BMI (p>0.05).

Comparison of diaphragm excursion, and PFM force between groups:

There was a significant increase in diaphragm excursion and PFM force in group B compared to group A (p < 0.01) (Table 1). There was a significant moderate positive correlation between Diaphragm and pelvic floor muscles (R=0.64). (Table 2).

6. Discussion

Urinary incontinence (UI) is common in women [43]. There may be a relationship between LBP and UI.

There was a significant increase in diaphragm excursion and PFM force in group B compared with that in group A, and there was a significant moderately positive correlation between PFM strength and diaphragm excursion. Our results also point out that there is a decrease in diaphragm excursion in women with UI. In addition, there is a correlation between PFM force and diaphragm excursion.

The PFM and diaphragm can be deliberately recruited and contracted independently during expiration and inspiration, effectively opposing the contractions of the deep trunk muscles. Sometimes in human life, such antagonistic muscle action is required, such as when voluntarily supporting the evacuation of urine and stool or during labor and childbirth, which begins with a deep inhalation to relax the deep abdominal muscles and PFMs and open the pelvic orifices [44]. This study explained that the diaphragm is in the upper abdomen and the

PFM is in the lower abdomen, forming the abdominal cavity, which looks like a balloon. Because of its shape, the PFM works with the muscles in the abdomen region to contract [45, 46]. The diaphragm and PFM move in synchronous parallel, and the movement of both muscles is synchronous craniocaudal [47].

Another explanation to support this result [30, 48] is that PFM is part of IAP and has a respiratory role. According to this study [30], when the abdominal muscles are powerfully contracted, the diaphragm moves upward, and the PFM moves down. This research [48] explained that when the abdominal muscles are powerfully contracted, the diaphragm moves higher, and the elevated IAP causes a contraction of the PFM. Their activity increases as intra-abdominal pressure rises during coughing or forced exhalations [49]. The pelvic floor plays a critical role as a synergist for the diaphragm and abdominal muscles to operate efficiently together to maintain IAP [29].

As a result, the PFM relaxes during inspiration but contracts to protect the internal organs when the IAP rises sharply. The PFM contracts, and the IAP rises even during a forced expiration time, causing the diaphragm to migrate higher. As a result, the PFM, diaphragm, and abdominal muscles should be in control of responding to and regulating changes in the IAP. When PFMs contract and relax in rhythm with the diaphragm during inhalation and exhalation, there is a strong link between them [47]. Some limitations exist for this study, the small sample size and the lack of skill in the motor control of the pelvic diaphragm.

CONCLUSIONS

Compared to normal individuals, there is a significant reduction in diaphragm and PFM activities in women with LBP associated with UI. PFM strength (force) and diaphragm excursion in females should be considered in LBP associated with UI.

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None.

CONFLICT OF INTEREST:

None.

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