Evaluation of Pelvic Floor Dysfunction in Women Using 3D Transperineal Ultrasound at South Valley University Hospital

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Abstract

Background: Dysfunction of the pelvic floor causes incontinence and prolapse, affecting stability, continence, and sexual function. Transperineal ultrasonography (TPU) is the gold standard for detecting these problems, offering accurate 2D and 3D imaging during dynamic movements.

Objectives: To evaluate the effectiveness of 3D transperineal ultrasound as a diagnostic modality in the assessment of pelvic floor dysfunction.

Patients and methods: This cross-sectional research at Qena University Hospital from March 2023 to March 2024 included women with pelvic floor dysfunction symptoms having 3D transperineal ultrasonography, omitting pregnant women and those with current infections. To guarantee statistical power, 75 samples were computed. Medical history, pelvic floor therapy, and associated conditions were assessed. Pelvic structures, levator hiatal diameters, and anomalies were imaged utilizing a GE Voluson P8 system with 2D and 3D transducers. Morphometry changes during movements were examined for pelvic organ prolapse and other problems.

Results: Dysfunction (n=48) and normal (n=27) groups differed significantly. The dysfunction group had greater menopausal status (66.67% vs. 14.81%), longer age (53.63 vs. 38.11 years, $p<0.0001$), and more children (81.25% vs. 18.52%, $p<0.0001$). Symptoms included protruding bulk (52.08%, $p<0.0001$), urinary (66.67%, $p<0.0001$), fecal difficulties (47.92%, $p<0.0001$), and sexual dysfunction (22.92%, $p=0.0066$ Imaging showed considerable cystocele, hiatal area, and dynamic alterations during Valsalva maneuver ($p<0.0001$).

Conclusion: TPU is a valuable tool for diagnosing and monitoring pelvic floor dysfunction, offering detailed insights into anatomical and functional changes, including during dynamic conditions.

Keywords: Pelvic Floor Dysfunction; 3D Ultrasound; Transperineal.

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Introduction

The pelvic floor consists of an integrated system of muscles, ligaments, and fascia, playing a crucial role in maintaining pelvic girdle stability, muscle tone, continence, urination, defecation, and sexual function **(Peinado-Molina et al., 2023).** Pelvic floor dysfunction, a multifaceted condition, is linked to urinary incontinence, bladder emptying disorders, pelvic organ prolapse, sexual dysfunction, chronic pelvic pain, fecal incontinence, and bowel emptying disorders **(Okeahialam et al., 2022).**

Imaging techniques are essential for evaluating pelvic floor anatomy, with transperineal ultrasound (TPU) recognized as the gold standard for detecting dysfunctions in the anterior, central, or posterior compartments of the female pelvic region **(Barca et al., 2022; Shui et al., 2020).** The assessment of pelvic floor function poses challenges due to the subjectivity and poor reproducibility of clinical evaluations. However, numerous studies have confirmed the reliability and reproducibility of TPU in assessing pelvic floor muscle integrity and function under both static and dynamic conditions, including during the Valsalva maneuver **(Brunelli et al., 2020).**

TPU provides consistent imaging that supports the thorough evaluation needed for diagnosing and managing urogynecological conditions. It offers two-dimensional sagittal views of the bladder neck, urethra, and pelvic floor, two-dimensional coronal views of the anal canal, and three- or four-dimensional views of the genital hiatus and anal canal **(Retief et al., 2022).**

The main aim of our study was to evaluate the effectiveness of 3D transperineal ultrasound as a diagnostic modality in the assessment of pelvic floor dysfunction.

Patients and methods

This cross-sectional study was conducted at the Fetal Medicine Unit, Obstetrics and Gynecology Department, Qena University Hospital, South Valley University, from March 2023 to March 2024. The study included women of any age with symptoms of pelvic floor dysfunction, scheduled for 3D transperineal ultrasound, while excluding pregnant women and those with active pelvic infections. Based on a prior study by **Raimondo et al. (2017),** the sample size was calculated using Epi Info STATCALC formula $n = (Z^2 * P(1 - P)) / d^2$ where $Z = 1.96$, P is the estimated proportion, and $d = 0.05$, resulting in a sample size of 75 to account for potential dropouts.

We selected women with probable pelvic floor dysfunction from our gynecological outpatient practice. The investigation was done in tertiary care. Each participant had a thorough medical history, including age, parity, menopausal status, gynecological operations, pelvic floor therapies, and triggering conditions such persistent cough or constipation. Also documented were urine or fecal incontinence, pelvic discomfort, and sexual dysfunction.

The patient's vital signs, BMI, and overall status were examined, with a focus on mesenchymal weakness in congenital prolapse. Flat feet, varicose veins, umbilical hernia, ptosed liver, and spina bifida were seen.

Divercation of recti, umbilical hernia, ascites, pelviabdominal tumors, and hysterectomy or hernioplasty scars were checked during an abdominal exam. Finally, a pelvic exam assessed pelvic organ prolapse, stress urine incontinence, and muscular strength **(Blomquist et al., 2020).**

Imaging Technique

After obtaining informed consent, patients were instructed to empty their bladders before the examination. The perineal area was then cleaned with an antiseptic solution, and ultrasound gel was applied to both the transducer and the area of interest.

The imaging was performed using a GE Voluson P8 machine. A conventional convex 2D transducer (3–6 MHz) with a field of view of at least 70° was used. For tomographic or multi-slice imaging, a volumetric probe (4–8 MHz) was employed, with the transducer covered by a glove or thin plastic wrap **(Santoro et al., 2022).**

Image acquisition and analysis

For 2D ultrasound imaging **(Figs. 1, 2),** a transperineal midsagittal view was obtained with the transducer covered and placed on the perineum. Imaging was conducted in the dorsal lithotomy or standing position, ensuring a clear view of the symphysis pubis, urethra, bladder neck, vagina, cervix, rectum, anal canal, and cul-de-sac. Care was taken to avoid air bubbles that could cause artifacts.

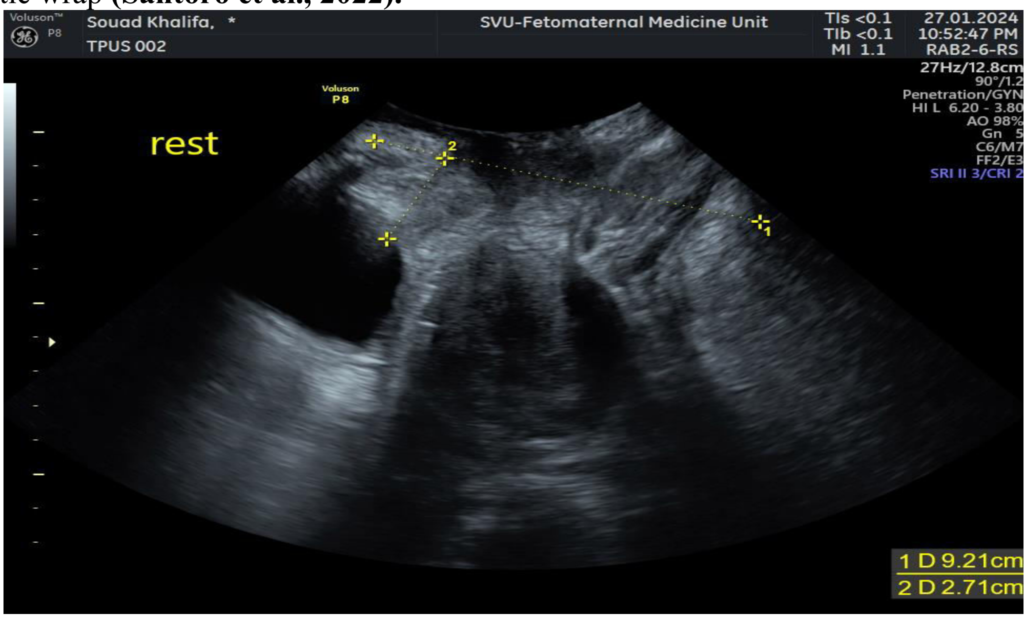

Fig .1. 2D TPUS at rest.

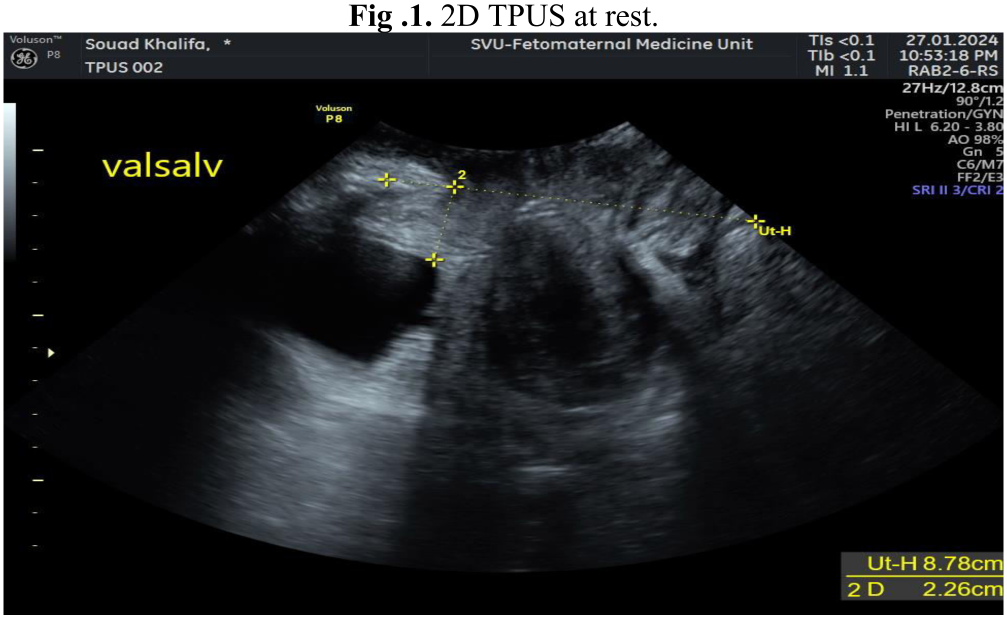

Fig .2. 2D TPUS during Valsalva

For 3D ultrasound imaging, the volume was acquired in the modified lithotomy position with the bladder empty. The convex volumetric transducer was positioned trans-labially in the midsagittal plane, capturing the levator hiatus and surrounding structures. Measurements were analyzed offline, assessing the levator hiatal area, anteroposterior and transverse diameters at rest, during maximum pelvic floor contraction, and during the Valsalva maneuver **(Fig.3).** The changes in morphometry were calculated as a percentage change from baseline, with coactivation of the levator ani muscle evaluated during the Valsalva maneuver.

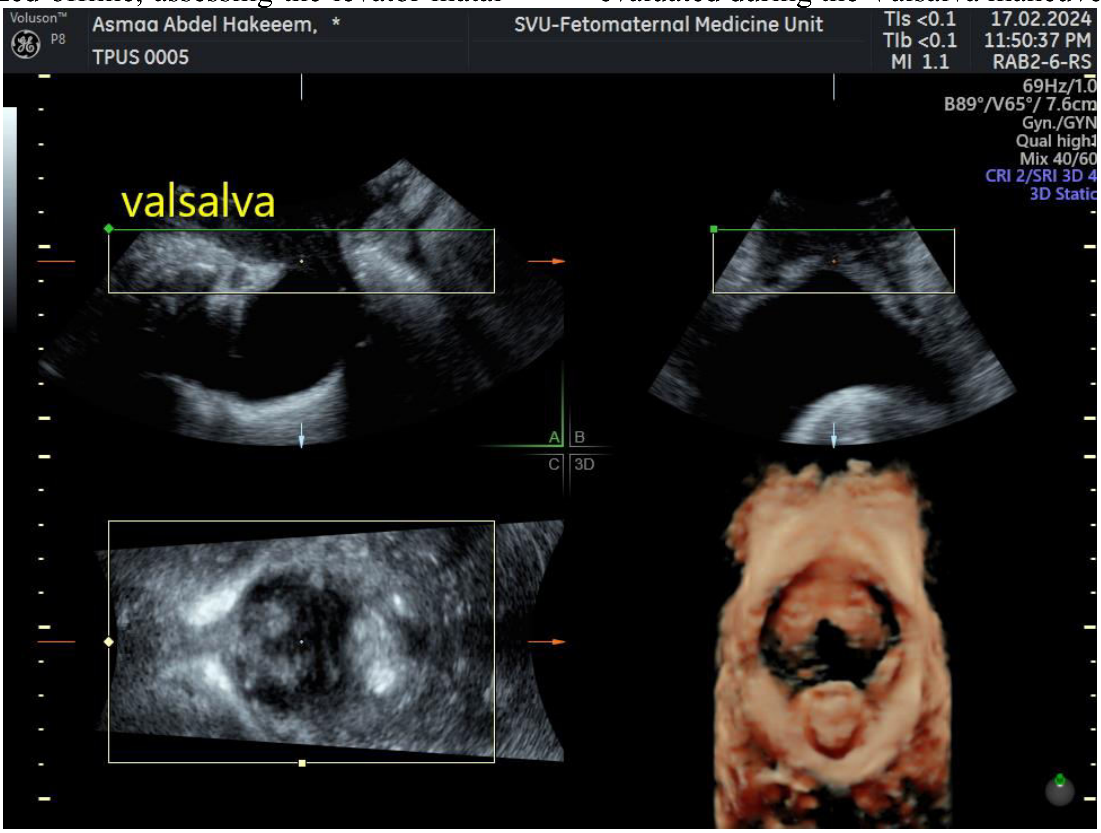

Fig 3. Acquisition of a rendered volume of the Levator Hiatus

Image analysis

Multiplanar reconstruction provided sagittal, coronal, and axial views of the pelvic floor structures. The levator ani muscles, urethra, vagina, and rectum were assessed for abnormalities, and the anorectal angle, hiatal dimensions, and bladder neck descent during Valsalva were measured **(Fig. 4, 5)**. Pelvic organ prolapse was evaluated using standardized staging systems like POP-Q, and the anal sphincter complex was assessed, particularly in cases of fecal incontinence or perineal trauma **(Fig. 6).**

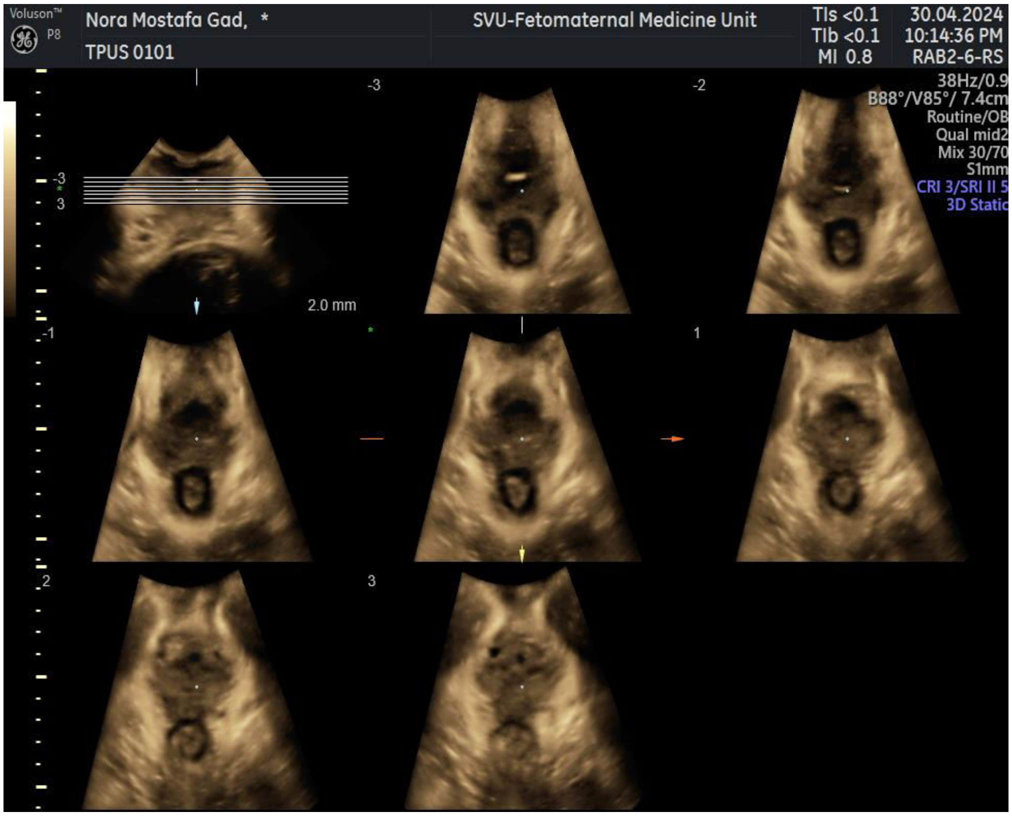

Fig .4. Obtaining tomographic imaging of the levator ani.

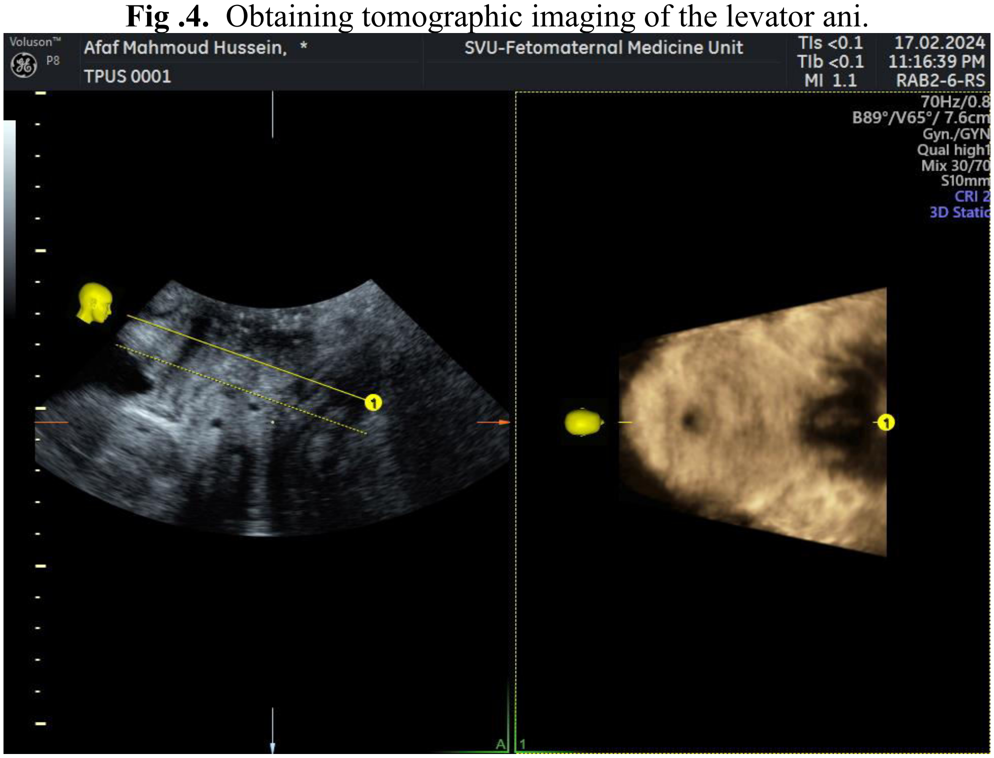

Fig 5. Obtaining omniview imaging of the levator ani.

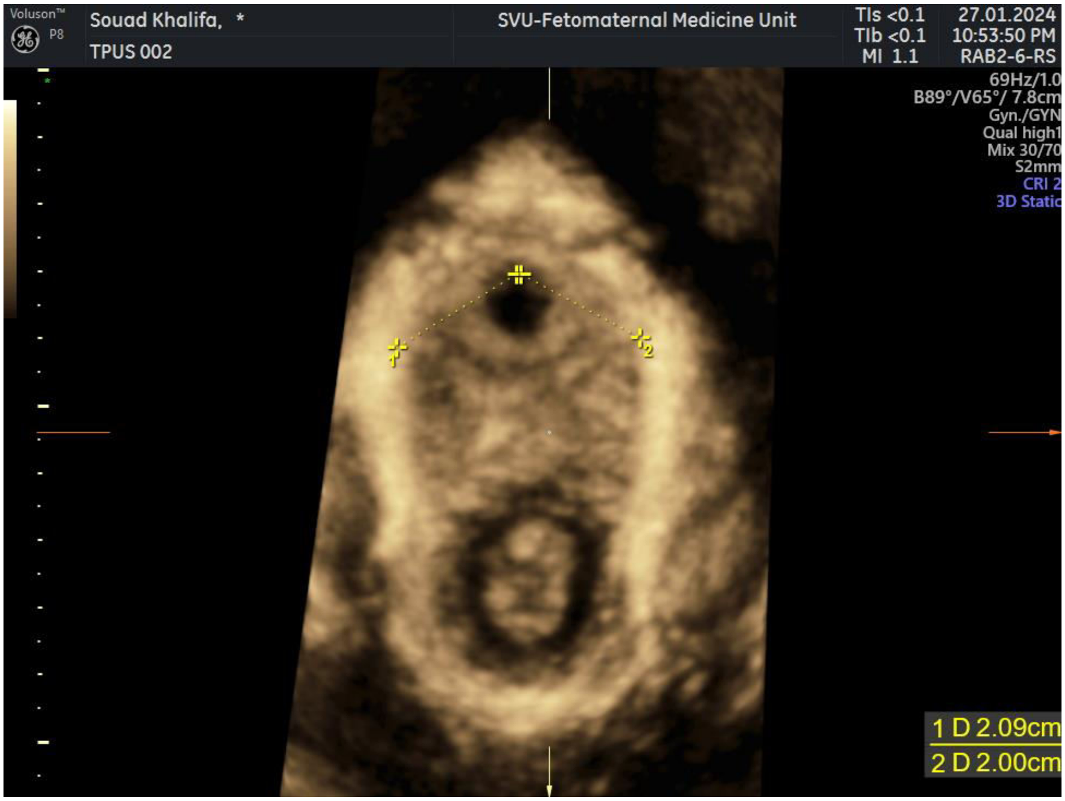

Fig 6. 3D TPUS measuring of right and left levator urethral gap.

Documentation and Reporting: Relevant 2D and 3D images and measurements were saved. A detailed report was generated, documenting the ultrasound findings, including any identified abnormalities or defects.

Ethical approval code: SVU-MED-OBG024-1-24-8-911.

Statistical analysis

Data were analyzed using SPSS version 26. Qualitative variables were expressed as numbers and percentages, while quantitative ones as mean ± SD. Chi-sqaure test (X) was applied for qualitative data comparison, Mann-Whitney Test (MWU) for non-normally distributed quantitative data between two groups, T-Test for normally distributed data, and Ficher exact test (f) for small sample sizes. A p-value < 0.05 was deemed statistically significant.

Results

The study included 75 women with a mean age of 48.04 years (SD ± 12.69). The average parity was 3.99 (SD ± 2.69), with the distribution as follows: 14 women (18.67%) had no children, 3 women (4%) had one child, 6 women (8%) had two children, 8 women (10.67%) had three children, and 44 women (58.67%) had four children or more. Of the participants, 36 (48%) were menopausal. Regarding previous surgeries, 17 women (22.67%) had undergone cesarean sections, 9 women (12%) had myomectomies, 11 women (14.67%) had hernioplasties. The mean body mass index (BMI) of the participants was 24.03 (SD ± 1.68), (**Table .1).**

Table 1. Demographic characteristics

Variables	Value (N = 75)
Age (Years) (Mean ± SD)	48.04 ± 12.69
Parity (Mean ± SD)	3.99 ± 2.69
Nullipara	14 (18.67%)
1	3 (4%)
2	6 (8%)
3	8 (10.67%)
≥4	44 (58.67%)
Menopausal (No. %)	36 (48%)
Previous operations (No. %)	
CS	17 (22.67%)
Myomectomy	9 (12%)
Hernioplasty	11 (14.67%)
BMI (Mean ± SD)	24.03 ± 1.68

The dysfunction group had a higher mean age (53.63 years) compared to the normal group (38.11 years, $p < 0.0001$). Nulliparity was less common in the dysfunction group (6.25%) than in the normal group (40.74%, $p = 0.0001$). Women with one or two children were absent in the dysfunction group but present in the normal group (11.11% and 22.22%, $p = 0.0433$ and $p = 0.0015$, respectively). More than three children were more common in the dysfunction group (81.25%) compared to the normal group (18.52%, $p < 0.0001$). Menopausal status was higher in the dysfunction group (66.67%) than in the normal group (14.81%, $p < 0.0001$). No significant differences were observed in previous operations, including cesarean sections (18.75% vs. 29.63%, $p = 0.2863$), myomectomies (10.42% vs. 14.81%, $p = 0.5798$), and hernioplasties (16.67% vs. 11.11%, $p = 0.5204$). Mean BMI was similar between the dysfunction (23.79) and normal groups (24.46, $p = 0.0869$), (**Table. 2).**

Table 2. Comparison between Cases with and without Pelvic Dysfunction regarding General evaluation

Variables	Dysfunction Group (N = 48)	Normal Group (N = 27)	P. Value
Age (Years) (M±SD)	53.63 ± 10.64	38.11 ± 9.61	<0.0001*[MWU]
Parity (No.%)			
Nulli para	3 (6.25%)	11 (40.74%)	0.0001*[X]
1	0 (0%)	3 (11.11%)	0.0433*[f]
2	0 (0%)	6 (22.22%)	0.0015*[f]
3	6 (12.5%)	2 (7.41%)	0.4995[X]
≥4	39 (81.25%)	5 (18.52%)	<0.0001*[X]
Menopausal (No.%)	32 (66.67%)	4 (14.81%)	<0.0001*[X]
Previous operations (No.%)			
CS	9 (18.75%)	8 (29.63%)	0.2863[X]
Myomectomy	5 (10.42%)	4 (14.81%)	0.5798[X]
Hernioplasty	8 (16.67%)	3 (11.11%)	0.5204[X]

BMI (M±SD)	23.79 ± 1.67	24.46 ± 1.6	0.0869[MWU]

Divercation was significantly higher in the dysfunction group (43.75%, n=21) compared to the normal group (14.81%, n=4) with a P-value of 0.0103. Pelviabdominal mass was observed in 18.75% (n=9) of the dysfunction group and 37.04% (n=10) of the normal group, but this difference was not statistically significant (P=0.0825). Myomectomy scars were present in 8.33% (n=4) of the dysfunction group and 11.11% (n=3) of the normal group, with a P-value of 0.6914, indicating no significant difference. Hernioplasty scars were found in 14.58% (n=7) of the dysfunction group and 14.81% (n=4) of the normal group, with a P-value of 0.978, also showing no significant difference, (**Table .3).**

Table 3. Comparison between Cases with and without Pelvic Dysfunction regarding Abdominal Examination findings

Variables	**Dysfunction Group (N = 48)**	**Normal Group (N = 27)**	**P. Value**
Divercation (No.%)	21 (43.75%)	4 (14.81%)	0.0103*[X]
Pelviabdominal mass (No.%)	9 (18.75%)	10 (37.04%)	0.0825[X]
Scars (No.%)			
Myomectomy scars	4 (8.33%)	3 (11.11%)	0.6914[X]
Hernioplasty scars	7 (14.58%)	4 (14.81%)	0.978[X]

Comparison between cases with and without pelvic dysfunction regarding transperineal ultrasound (TPUS) findings revealed significant differences. At rest, the dysfunction group (N = 48) showed a significant increase in Cystocele (2.43 ± 0.29 vs. 1.98 ± 0.23, p < 0.0001), while right and left levator urethra gap (LUG) significantly increased compared to the normal group (p < 0.0001). Hiatal area also showed a significant increase in the dysfunction group (8.48 ± 0.88 vs. 7.66 ± 0.85, p = 0.0002), (**Table.4).**

Table 4. Comparison between Cases with and without Pelvic Dysfunction regarding TPUS Findings (at rest)

Variables	**Dysfunction Group (N = 48)**	**Normal Group (N = 27)**	**P .Value**
2D US (M±SD)			
LH diameter	7.36 ± 1.02	7.19 ± 0.65	0.9384[MWU]
BN descent	2.43 ± 0.29	1.98 ± 0.23	<0.0001*[s.t]
3D US (M±SD)			
Right LUG	2.79 ± 0.45	2.07 ± 0.23	<0.0001*[w.t]
Left LUG	2.81 ± 0.36	2.09 ± 0.25	<0.0001*[w.t]
Hiatal Area	8.48 ± 0.88	7.66 ± 0.85	0.0002*[s.t]

Significant differences were observed in several parameters. During Valsalva, individuals in the dysfunction group exhibited significantly larger levator hiatus (LH) diameter (8.52 ± 1.05 mm) compared to those in the normal group (7.65 ± 0.83 mm; p = 0.0003). The bladder neck descent was significantly higher in the dysfunction group (2.2 ± 0.4 cm) than in the normal group (1.4 ± 0.37 cm; p = 0.0001). Measurements of the right levator urethral gap (LUG) were significantly decreased in the normal group (3.24 ± 0.27) compared to the dysfunction group (5.09 ± 0.35; $p < 0.0001$), with no significant difference observed for the left LUG. The hiatal area was notably larger in the dysfunction group (29.35 ± 5.37 cm²) than in the normal group (20.92 ± 2.29 cm²; $p < 0.0001$). Regarding 3D US findings, significant increases were found in the dysfunction group for cystocele (100% vs. 0%), cystourethrocele (18.75% vs. 0%), uterine descent (81.25% vs. 0%), rectocele (36% vs. 0%), LAM avulsion (87.5% vs. 0%), and hiatal ballooning (100% vs. 0%), all with $p < 0.0001$, (**Table. 5).**

Table 5. Comparison between Cases with and without Pelvic Dysfunction regarding TPUS Findings (During Valsalva)

Variables	Dysfunction Group (N = 48)	Normal Group (N = 27)	P. Value
2D US (M±SD)			
LH diameter	8.52 ± 1.05	7.65 ± 0.83	0.0003*[s.t]
BN descent	2.2 ± 0.4	1.4 ± 0.37	0.0001*[s.t]
3D US (M±SD)			
Right LUG	5.09 ± 0.35	3.24 ± 0.27	<0.0001*[MWU]
Left LUG	5.16 ± 0.32	5.15 ± 0.2	0.8837 MWU]
Hiatal Area	29.35 ± 5.37	20.92 ± 2.29	<0.0001*[MWU]
3D US findings (No.%)			
Cystocele	48 (100%)	0 (0%)	<0.0001*[f]
Cystourethrocele	9 (18.75%)	0 (0%)	0.0162[f]
Uterine descent	39 (81.25%)	0 (0%)	<0.0001*[f]
Rectocele	27 (36%)	0 (0%)	<0.0001*[f]
LAM avulsion	42 (87.5%)	0 (0%)	<0.0001*[f]
Hiatal Ballooning	48 (100%)	0 (0%)	<0.0001*[f]

Discussion

In our study of 75 women, 48 with pelvic floor dysfunction and 27 without, those with dysfunction were significantly older (mean age 53.63 years) compared to the normal group (mean age 38.11 years). Additionally, the dysfunction group had higher parity, indicating a greater number of pregnancies. More premenopausal women were observed in the dysfunction group, while previous surgeries, predisposing factors, and BMI showed no significant differences between the two groups.

These differences in age and parity may explain why pelvic floor dysfunction is more common among older women with multiple pregnancies. As women age, the pelvic floor's collagen and elastin fibers deteriorate, weakening support structures and reducing elasticity. Hormonal changes, particularly reduced estrogen levels during menopause, further contribute to this weakening. The mechanical stress from multiple pregnancies and childbirth can stretch and damage pelvic muscles and ligaments, leading to decreased muscle tone and increased dysfunction risk **(Peinado-Molina et al., 2023).**

Our study findings align with those of **Raimondo et al. (2017),** who found no significant differences in BMI and dysmenorrhea between the intervention (n=17) and non-intervention (n=13) groups in a study of pelvic floor muscle dysfunction using 3D/4D transperineal ultrasound in patients with deep infiltrating endometriosis ($p>0.05$). However, unlike our study, Raimondo et al. reported no significant age difference, with a mean age of 32.8 ± 6.7 years in the control group and 32.5 ± 7.6 years in the subject group.

Similarly, our findings agree with **Madkour (2018),** who studied pelvic floor dysfunction in women using transperineal ultrasound imaging and found that multiparous women were more prevalent in the underactive pelvic floor muscle contraction (UPFMC) group (n=52) compared to the normal pelvic floor muscle contraction (NPFMC) group (n=21), with a significant difference in parity (p=0.03).

Our results also align with **Nygaard et al. (2008),** who examined the prevalence of symptomatic pelvic floor disorders in non-pregnant women (n=1961). They observed that the prevalence of these disorders increased with age, from 9.7% in women aged 20-39 years to 49.7% in those aged 80 years or older (p<0.001). Similarly, the prevalence increased with parity: 18.4% for nulliparous women, 24.6% for one delivery, and 32.4% for three or more deliveries (p<0.001).

In our study, the dysfunction group showed a significantly higher prevalence of divarication (p = 0.0103), but there were no significant differences in palpable abdominal masses, myomectomy scars, or hernioplasty scars. Both groups had no cases of hernia or ascites. The dysfunction group exhibited higher rates of protruding mass (p < 0.0001), dysuria (p = 0.0009), stress urinary incontinence (SUI) (p = 0.0162), urge incontinence (p = 0.0248), dyschezia (p = 0.0162), constipation (p = 0.0248), and sexual dysfunction (p = 0.0066). Furthermore, the dysfunction group had higher incidences of pelvic organ prolapse (POP), cystocele, cystourethrocele, and rectocele, all with p < 0.0001, except cystourethrocele (p = 0.0162).

Our study findings are consistent with **Hainsworth et al. (2017),** who reported that out of 323 patients undergoing transperineal ultrasound (TP US) during the Valsalva maneuver, 72 (22.29%) showed rectocele. This suggests a higher prevalence in our study. Compared to Madkour (2018), who found a lower prevalence of POP at 71%, fecal incontinence at 5.5%, and sexual dysfunction at 5.5%, our study showed a higher prevalence. However, SUI prevalence was higher in Madkour's study at 49.3%.

Our study findings also correlate with **Nygaard et al. (2008),** who reported that among 1961 non-pregnant women, 23.7% had at least one pelvic floor disorder, with 15.7% experiencing urinary incontinence, 9.0% experiencing fecal incontinence, and 2.9% experiencing POP.

In contrast, **Liu et al. (2014)** found a lower prevalence of POP using 3D ultrasound, with only 21.28% in the vaginal delivery group and 4.17% in the cesarean section group. Twelve cases of cystocele were observed, mainly in the vaginal delivery group, which is less than what was observed in our study.

Our study findings revealed significant differences in transperineal ultrasound (TPUS) measurements at rest and during the Valsalva maneuver between women with and without pelvic dysfunction. At rest, the dysfunction group exhibited greater bladder neck (BN) descent (2.43 vs. 1.98, p < 0.0001), larger right and left levator urethral gaps (LUG) (2.79 and 2.81 vs. 2.07 and 2.09, p < 0.0001), and a larger hiatal area (8.48 vs. 7.66, p = 0.0002). During the Valsalva maneuver, the dysfunction group showed larger levator hiatus (LH) diameter (8.52 vs. 7.65, p = 0.0003), BN descent (2.2 vs. 1.4, p = 0.0001), right and left LUG (5.09 and 5.16 vs. 3.24 and 5.15, p < 0.0001), and hiatal area (29.35 vs. 20.92, p < 0.0001). Additionally, cystocele (100%), uterine descent (81.25%), rectocele (36%), levator ani muscle (LAM) avulsion (87.5%), and hiatal ballooning (100%) were significantly more prevalent in the dysfunction group (all $p < 0.0001$).

Our study findings align with **Raimondo et al. (2017),** who observed higher percentage changes in levator hiatal area at rest and during maximum Valsalva maneuver among women in the study group (n=17) compared to controls (n=13), favoring Valsalva (P = 0.02). This supports our findings regarding increased LHA during Valsalva.

Liu et al. (2014) also support our findings. They investigated the levator hiatus in postpartum (n=95) and nulliparous women (n=50) using 3D ultrasound, noting significant differences in the hiatus size at rest (19.94 vs. 12.71) and during Valsalva (23.13 vs. 15.50). Postpartum women had an enlarged, circular-shaped levator hiatus, similar to the changes we observed in our study.

Van Delft et al. (2014) reported that LAM avulsion was found in 21% of vaginal deliveries among 191 primigravida women who returned postpartum, highlighting the higher prevalence of LAM avulsion in our study (87.5%). Our findings also agree with **Ying et al. (2012),** who found that the levator hiatus in women with pelvic organ prolapse (POP) was significantly larger at rest (17.01 mm) and during Valsalva (22.76 mm) than in nulliparous women, and that the pelvic floor size increased, with abnormal pelvic organ arrangement in 46% of cases.

Despite its strengths, our study has several limitations that warrant consideration. First, the sample size of 75 subjects may limit the generalizability of our findings to broader populations. Additionally, the study's cross-sectional design restricts our ability to establish causality or assess longitudinal changes in pelvic floor dysfunction over time. Moreover, while TPUS offers detailed anatomical insights, its ability to comprehensively evaluate functional aspects, such as muscle strength and coordination, remains somewhat limited. Lastly, the study primarily focused on TPUS findings without extensive integration with other diagnostic modalities or clinical outcomes, potentially influencing the completeness of our findings. Future research addressing these limitations could further elucidate the role of TPUS in comprehensive pelvic floor assessment.

Conclusion

Transperineal ultrasound (TPUS) is crucial for evaluating pelvic floor function by providing detailed imaging of pelvic structures. It detects static and dynamic abnormalities like prolapse or urethral hypermobility, guiding treatment decisions and improving patient management through its non-invasive, diagnostic capabilities.

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