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The Effect of Pelvic Floor Sonography Biofeedback on Pelvic Floor Muscle Contractions

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Abstract

Background: *Proper functioning of the pelvic floor muscles is an important element of the urogynecological therapy. There are different methods available to teach women pelvic floor muscles contractions (PFMC), but there is still no consensus in which situations they should be used in the clinical practice.*

Objectives: *The aim of the study was to assess the usefulness of pelvic floor ultrasound performed introitally with transvaginal probe (PFS-TV) for teaching PFMC. An additional aim was to check whether the avulsion of the puborectalis muscle as well as the grade of muscle contractility have an influence on the learning process.*

Material and methods: *The analysis was carried out on the basis of 116 patients aged between 27 and 84 years (average age 59). Levator contraction strength was assessed during palpation, using the Modified Oxford Grading (MOS) before and after teaching PFMCs. PFS-TV was used to evaluate urethral mobility (UM) parameters and to teach PFMC (ultrasound biofeedback). Levator ani muscle (LAM) trauma was identified at tomographic ultrasound (TUI) during 4D assessment.*

Results: *Teaching PFMC using ultrasound biofeedback (PFS-TV) resulted in an improvement of all urethral mobility parameters, positive effect on UM was observed in women with different grades of MOS. In women without avulsion and with avulsion, there was an improvement observed in UM parameters on a comparable level.*

Conclusions: *PFS-TV can be useful in teaching PFMC. Avulsion and MOS grade seemed to have no influence on the learning effect of PFMC when ultrasound biofeedback was used. Evaluating UM during pelvic floor sonography using three ultrasound parameters (H, D, and vector) can yield more comprehensive information than one parameter H.*

Key words: *pelvic floor ultrasound, pelvic floor sonography, pelvic floor muscle contraction, Modified Oxford Scale, ultrasound biofeedback*

Introduction

Most common diseases affecting the female population worldwide include urogynecological complaints: urinary incontinence (UI), overactive bladder (OAB), and pelvic organ prolapse (POP) [1, 2]. The risk of developing urogynecological conditions during one's lifetime is 30–40% [3, 4]. Non-operative treatment is recommended as first-line therapy. If it is ineffective, the patient is referred for surgery [4]. Pelvic floor muscle training (PFMT), called Kegel's exercises, is widely prescribed to treat stress urinary incontinence (SUI), POP, and to prevent recurrence after urogynecological operations [5, 6, 7]. PFMT effectiveness depends on the skilled and regular performance of the exercises [8]. The exercises can be taught through written instructions, by the physiotherapist with or without special electrostimulation and biofeedback exercise equipment [9, 10]. Instructions alone may lead to mistakes in performing exercises, resulting not only in lack of effects, but, in some cases, also in aggravated symptoms [11, 12]. Many specialists use sonography to teach PFMT in everyday practice, but knowledge of the technique usefulness is insufficient [5, 6, 7, 13, 14, 15, 16, 17]. Thus, the exercises are usually taught by a specialist. There is currently no consensus on the optimum PFMC teaching methods as knowledge of the methods is too limited.

PFMT effectiveness can be assessed using additional equipment, e.g., perineometer, EMG-biofeedback, ultrasound machine, or without additional devices [5, 6, 18, 19, 20, 21]. One of the methods to digitally assess pelvic floor muscle contraction strength is the Modified Oxford Scale (MOS) [15, 16]. MOS shows good repeatability and reproducibility as well as good correlation with sonographic assessment of changes in urogenital hiatus dimensions during pelvic floor muscle contractions (PFMCs) [17, 22].

Ultrasound evaluation of the pelvic floor is more often used in urogynecological practice by physicians and physiotherapists, as well as in studies. It allows real-time structure assessment with possibility of numerous repetitions. The literature offers many works on static and dynamic pelvic floor evaluation applying 2D, 3D, and 4D pelvic floor ultrasound performed with transabdominal probe (PFU-TA) [15, 23]. PFU-TA enables comprehensive pelvic floor evaluation in a single image. A disadvantage is the scarcity of 4D probes in use and a small number of specialists skilled in the use of this examination technique. More and more scientific analyses concern 2D pelvic floor sonography performed with transvaginal probe (PFS-TV). Its advantages include, among others, a large number of specialists using transvaginal probes, equipment availability and the minimum surface of probe pressure on the urethra. PFS-TV does not allow comprehensive pelvic floor evaluation in a single image [24, 25]. Studies indicate the usefulness of PFU-TV in visual biofeedback [17]. Knowledge of PFS-TV usefulness for that purpose is scarce [25].

Levator ani muscle (LAM) are crucial in preventing the descent of pelvic organs. LAM partial detachment has no clinical influence on pelvic floor, while LAM total detachment – avulsion, is a risk factor of POP and failure after POP operations. Influence of avulsion on PFMT, urethral mobility (UM), urinary, and stool incontinence is still not clear [26, 27, 28]. Avulsion can be evaluated using 4D PFU-TA and clinical examination, but PFU-TA is dedicated for studies as more accurate [26].

The aim of the study was to assess the usefulness of pelvic floor ultrasound performed introitally with transvaginal probe for teaching PFMC. An additional aim was to check whether the avulsion of the puborectalis muscle and the grade of muscle contractility have the influence on the learning process.

Material and methods

A retrospective analysis of data obtained from 116 women who attended the urogynecology outpatient unit for non-operative treatment between January 2019 and December 2019 was performed.

All patients had a standardized, nonvalidated interview and a clinical examination using the ICS POP-Q scale [29]. All evaluated results of the examinations in this study were performed in women with an empty bladder. GE Kretz Voluson 730 expert and Voluson 730 Pro 4D were used for 4D PFU-TA (abdominal probe GE RAB4-8L Convex 4-8 MHz) and 2D PFS-TV (transvaginal probe GE RIC5-9E 5-9 MHz) [15, 23, 25, 30].

Levator contraction strength was assessed during palpation, using the Modified Oxford Grading (MOS) (Table 1) [31]. MOS evaluation was performed after ultrasound evaluation before and after teaching PFMC. MOS was evaluated by another specialist, blinded to ultrasound results. Also, the ultrasound specialist was not informed about MOS examination results.

Table 1. Modified Oxford Scale

Grading	Description
0	No discernible PFMC
1	A very weak PFMC
2	A weak PFMC
3	A moderate PFMC
4	A good PFMC
5	A strong PFMC

Source: [31].

Before teaching PFMC, during PFU-TA, levator trauma was identified at tomographic ultrasound (TUI) view as previously described. Avulsion was diagnosed in women with uni- or bilateral total detachment. Partial detachment was not a sign of avulsion [15, 32, 33].

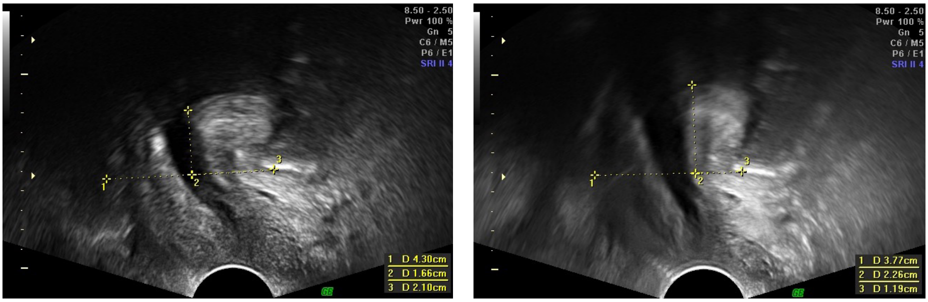
Before, after and during teaching PFMC, PFS-TV was performed with the standardized technique developed by Kociszewski in women with an empty bladder. During UM evaluation, the patient did not see the ultrasound monitor. The internal urethral orifice location – bladder neck, was evaluated in XOY coordinate system at rest and at maximal PFMC, as previously described (Figure 1). Changes in the values of UM parameters (ΔH, ΔD and vector) were calculated according to the following, previously used, formulas:

- $\Delta H = H$ at PFMC – H at rest,
- $\Delta D = H$ at PFMC – D at rest,
- vector PFMC = sqrt $(\Delta H^2 + \Delta D^2)$.

The vector was calculated according to the formula as the hypotenuse of a perpendicular triangle, the sides of which were segments ΔD and ΔH [25, 34, 35].

For teaching the correct performing PFMC we used PFS-TV. During training women observed urethral movements on an ultrasound monitor and patients' mistakes were corrected. After a few minutes of guided PFMCs, UM was again measured during PFS-TV, and after that MOS was evaluated by another specialist.

Figure 1a, 1b. PFS-TV – the evaluation of the parameters of UM



Source: own elaboration.

A. at rest left

1 – auxiliary line from the lower edge of the pubic symphysis; 2 – parameter H of UM; 3 – parameter D of UM.

B. during PFMC – right

1 – auxiliary line from the lower edge of the pubic symphysis; 2 – parameter H of UM; 3 – parameter D of UM.

Ethical approval was obtained from the Ethics Committee of the Medical University of Lodz in Poland.

The statistical analysis of the obtained results was carried out using the Statistica ver. 13.3 (Medical University of Lodz license) and using the statistical functions of Excel from MS Office.

After examining the normality of the distribution of the obtained test results, the Student's t-test was performed to compare the differences between the mean values of the two groups. On the other hand, a paired t-test was used to compare the results before and after treatment.

To compare the significance of the fraction of the distribution of differences in the two study groups, a multifield c2 test was used.

The comparison of two series of measurements (after examining the normality of the distributions) was carried out using linear correlation analysis, the regression equation was determined, and the Pearson linear correlation coefficient was calculated. The significance of the correlation was examined using the Student's t-test.

The threshold of statistical significance was $p<0.05$.

Differences at the level of $p < 0.05$ were considered statistically significant.

In order to compare the two research methods, the Bland-Altman analysis was used.

The Bland-Altman coefficient shows what percentage of differences lie outside the area of <-1.96*SD; +1.96*SD>), if it is greater than 5%, it means that there is no good agreement between the two measurement methods, although there may be a statistically significant linear correlation between them.

Results

The mean age of the 116 women included in the analysis was 59 (27–84) years, BMI was 27.4 (17.6–39.3). Mean vaginal parity was 1 (0–4), and 92.9% were vaginally parous. A Vacuum or Forceps was reported by none of the patient. 8.6% of analyzed women had had a hysterectomy and 17.6% had urogynecological surgeries. 50% of patients complained of stress urinary incontinence (SI), 26.7% of masked urinary incontinence, 28.4% of urge incontinence, 44.8% of frequency, 34.5% of nocturia, 33.6% of symptoms of voiding difficulty (hesitancy, straining, and stop-start voiding), and 95.7% of symptoms of prolapse (lump or dragging sensation). In 95.7% of women, we detected some form of prolapse of stage 2 or higher. Pelvic organ prolapse stage 1 according to POPQ was present in 4.3% of women, stage 2 in 52.6%, stage 3 in 31.9%, and stage 4 in 11.2% of women. On examination, at least stage 2 cystocele was found in 91.4%, central compartment in 44.8%, and rectocele in 48.3%. Mean Oxford grading was 1.75 (SD 1.1), mean bladder neck mobility during PFMC before training was 7.1 (SD 5.0) mmA total of 77 patients (66.4%) had an avulsion of the puborectalis muscle.

The values of the evaluated parameters of UM before and after teaching PFMC are presented in Table 2. There was observed statistically significant improvement in all three parameters: H, D, and vector.

Table 2. Comparison of UM parameters before and after PFS-TV biofeedback

	mean±SD	mean±SEM	Median	Max	Min	Paired t-test
H movKeg pre	6.94±10.90	6.94±1.01	6.3	23.4	-1.4	<0.05
H movKeg post	9.36±11.35	9.36±1.05	8.6	131.2	-4.8	<0.05
ΔH	2.42±10.86	2.42±1.01	0.8	131.7	-6.0	-
D movKeg pre	-4.53±10.62	-4.53±0.99	-4.5	13.2	-27.2	<0.001
D movKeg post	-5.67±10.94	-5.67±1,02	-5.4	13.3	-26.6	<0.001
ΔD	-1.14±10.74	-1.14±1.00	-0.9	7.7	-14.5	-
vector Keg pre	9.19±11.40	9.19±1.06	8.6	31.0	0.6	<0.01
vector Keg post	12.20±13.33	12.20±1.24	10.4	131.2	0.5	<0.01
Δvector Keg	3.01±12.26	3.01±1.14	1.1	130.6	-3.1	-

Source: own elaboration.

Legend:

H moveKeg pre – parameter H of UM during PFMC before the training

H moveKeg post – parameter H of UM during PFMC after the training

ΔH – parameter H of UM after training minus parameter H before training

D moveKeg pre – parameter D of UM during PFMC before the training

D moveKeg post – parameter D of UM during PFMC after the training

ΔD – parameter D of UM after training minus parameter D before training

vector Keg pre – vector of UM during Kegel exercises before the training

vector Keg post – vector of UM movement during Kegel exercises after the training

ΔKeg vector movement of UM after training minus vector movement of UM before training

The comparable analysis of the MOS groups revealed different results depending on the group (Table 3–5). Among women from MOS 0–1 group, only parameter D improved, what means that the patients moved the urethra better toward pubic symphysis. Improvement in parameter H and vector were observed, but did not reach statistical significance. Patients from group MOS 2–3 after training showed an improvement in all three UM parameters (H, D, vector), while in group MOS 4–5 an improvement was not statistically significant. But analysis of the changes of the values of the three UM parameters (ΔH, ΔD, Δvector) showed changes in UM in all three MOS groups, and differences among them were statistically non-significant.

Table 3. Comparison of UM parameters before and after PFS-TV biofeedback in group MOS 0–1

	mean±SD	mean±SEM	Median	Max	Min	Differential test
H movKeg pre MOS 0-1	2.96±11.82	2.96±1.62	3.5	7.3	-1.4	>0.05
H movKeg post MOS 0-1	6.49±12.51	6.49±1.72	3.8	131.2	-2.1	>0.05
ΔH (post-pre) MOS 0-1	3.52±11.55	3.52±1.59	0.5	130.7	-3.3	-
D movKeg pre MOS 0-1	-2.30±10.14	-2.30±1.39	-2.4	13.2	-11.5	<0.01
D movKeg post MOS 0-1	-3.48±10.59	-3.48±1.45	-3.7	13.3	-17.7	<0.01
ΔD (post-pre) MOS 0-1	-1.18±10.69	-1.18±1.47	-0.8	4.0	-14.5	-
vector Keg pre MOS 0-1	5.17±11.17	5.17±1.53	5.1	14.0	0.6	>0.05
vector Keg post MOS 0-1	9.25±13.12	9.25±1.80	6.7	131.2	0.5	>0.05
Δkeg (post-pre) MOS 0-1	11.99±5.97	11.99±0.82	11.9	26.9	0.5	-

Source: own elaboration.

Legend:

H moveKeg pre – parameter H of UM during PFMC before the training

H moveKeg post – parameter H of UM during PFMC after the training

ΔH (post-pre) – parameter H of UM after training minus parameter H before training

D moveKeg pre – parameter D of UM during PFMC before the training

D moveKeg post - parameter D of UM during PFMC after the training

ΔD (post-pre) – parameter D of UM after training minus parameter D before training

vector Keg pre – vector of UM during Kegel exercises before the training

vector Keg post – vector of UM movement during Kegel exercises after the training

ΔKeg (post-pre) – vector movement of UM after training minus vector movement of UM before training

Table 4. Comparison of UM parameters before and after PFS-TV biofeedback in group MOS 2–3

	mean±SD	mean±SEM	Median	Max	Min	Differential test
H movKeg pre MOS 2–3	9.05±8.31	9.05±1.12	8.7	16.2	1.2	<0.001
H movKeg post MOS 2–3	10.60±8.62	10.60±1.16	10.6	17.9	-4.8	<0.001
ΔH (post-pre) MOS 2–3	1.56±8.77	1.56±1.18	1.3	7.3	-6.0	-
D movKeg pre MOS 2-3	-5.50±9.38	-5.50±1.26	-5.6	3.0	-11.4	<0.01
D movKeg post MOS 2–3	-6.67±9.08	-6.67±1.22	-7.0	7.4	-15.5	<0.01
ΔD (post-pre) MOS 2–3	-1.17±7.08	-1.17±0.95	-1.1	7.7	-10.0	-
vector Keg pre MOS 2–3	11.02±4.49	11.02±0.60	10.6	17.4	1.2	<0.001
vector Keg post MOS 2–3	13.25±5.01	13.25±0.68	13.0	20.8	7.1	<0.001
Δkeg (post-pre) MOS 2–3	12.20±5.96	12.20±0.80	12.0	26.9	0.5	-

Source: own elaboration.

Legend:

H moveKeg pre – parameter H of UM during PFMC before the training

H moveKeg post – parameter H of UM during PFMC after the training

ΔH (post-pre) – parameter H of UM after training minus parameter H before training

D moveKeg pre – parameter D of UM during PFMC before the training

D moveKeg post – parameter D of UM during PFMC after the training

ΔD (post-pre) – parameter D of UM after training minus parameter D before training

vector Keg pre – vector of UM during Kegel exercises before the training

vector Keg post – vector of UM movement during Kegel exercises after the training

ΔKeg (post-pre) – vector movement of UM after training minus vector movement of UM before training

Table 5. Comparison of UM parameters before and after PFS-TVbiofeedback in group MOS 4–5

	mean±SD	mean±SEM	Median	Max	Min	Differential test
H movKeg pre MOS 4–5	18.78±14.73	18.78±5.21	19.7	23.4	14.8	>0.05
H movKeg post MOS 4–5	19.81±15.04	19.81±5.32	20.4	25.6	14.8	>0.05
ΔH (post-pre) MOS 4–5	1.04±15.07	1.04±5.33	0.7	3.7	-0.5	-
D movKeg pre MOS 4–5	-12.64±16.20	-12.64±5.73	-10.4	-5.4	-27.2	>0.05
D movKeg post MOS 4–5	-13.34±15.20	-13.34±5.38	-10.8	-5.4	-26.6	>0.05
ΔD (post-pre) MOS 4–5	-0.70±11.26	-0.70±3.98	-0.4	1.2	-4.5	-
vector Keg pre MOS 4–5	23.30±8.43	23.30±2.98	22.2	31.0	17.8	>0.05
vector Keg post MOS 4–5	24.57±9.10	24.57±3.22	24.2	32.9	16.8	>0.05
Δkeg (post-pre) MOS 4–5	9.18±4.53	9.18±1.60	7.3	16.2	4.5	-

Source: own elaboration.

Legend:

H moveKeg pre – parameter H of UM during PFMC before the training

H moveKeg post – parameter H of UM during PFMC after the training

ΔH (post-pre) – parameter H of UM after training minus parameter H before training

D moveKeg pre – parameter D of UM during PFMC before the training

D moveKeg post – parameter D of UM during PFMC after the training

ΔD (post-pre) – in parameter D of UM after training minus parameter D before training

vector Keg pre – vector of UM during Kegel exercises before the training

vector Keg post – vector of UM movement during Kegel exercises after the training

ΔKeg (post-pre) – vector movement of UM after training minus vector movement of UM before training

In group MOS 0–1 after ultrasound biofeedback, in 22.6% (4/15) women MOS improved on 1 grade, the same effect was observed in 40% of women

(12/53) from group MOS 2–3. In group MOS 4–5, there were eight women in whom no change was observed.

In women without avulsion and with avulsion (Table 6–8), we observed an improvement in UM on a comparable level, so avulsion seems to have no negative influence on the learning process using PFS-TV biofeedback.

Table 6. Comparison of UM parameters before and after PFS-TV biofeedback in group without avulsion (PB0)

	mean±SD	mean±SEM	Median	Max	Min	Differential test
H movKeg pre PB0	7.65±8.00	7.65±1.32	6.8	23.4	-1.4	<0.001
H movKeg post PB0	9.18±8.10	9.18±1.33	9.2	25.6	-2.1	<0.001
D movKeg pre PB0	-5.05±8.56	-5.05±1.41	-5.1	13.1	-16.2	<0.01
D movKeg post PB0	-6.16±8.45	-6.16±1.39	-5.3	12.0	-20.7	<0.01
vector Keg pre PB0	9.94±7.01	9.94±1.15	9.8	28.5	0.8	<0.001
vector Keg post PB0	11.90±7.12	11.90±1.17	10.7	32.9	2.2	<0.001

Source: own elaboration.

Legend:

H moveKeg pre – parameter H of UM during PFMC before the training

H moveKeg post – parameter H of UM during PFMC after the training

D moveKeg pre – parameter D of UM during PFMC before the training

D moveKeg post – parameter D of UM during PFMC after the training

vector Keg pre – vector of UM during Kegel exercises before the training

vector Keg post – vector of UM movement during Kegel exercises after the training

Table 7. Comparison of UM parameters before and after PFS-TV biofeedback in group with avulsion (PB2)

	mean±SD	mean±SEM	Median	Max	Min	Differential test
H movKeg pre PB2	6.60±7.15	6.60±0.80	5.5	19.9	-1.4	<0.01
H movKeg post PB2	7.61±7.27	7.61±0.82	7.6	23.6	-4.8	<0.01
D movKeg pre PB2	-4.37±7.67	-4.37±0.86	-4.3	13.2	-27.2	<0.001
D movKeg post PB2	-5.33±7.55	-5.33±7.55	-5.4	13.3	-26.6	<0.001
vector Keg pre PB2	8.89±6.24	8.89±0.70	8.4	31.0	0.6	<0.001
vector Keg post PB2	10.51±6.41	10.51±0.72	9.8	30.5	0.5	<0.001

Source: own elaboration.

Legend:

H moveKeg pre – parameter H of UM during PFMC before the training

H moveKeg post – parameter H of UM during PFMC after the training

D moveKeg pre – parameter D of UM during PFMC before the training

D moveKeg post – parameter D of UM during PFMC after the training

vector Keg pre – vector of UM during Kegel exercises before the training

vector Keg post – vector of UM movement during Kegel exercises after the training

Table 8. Comparison of UM parameters before and after PFS-TV biofeedback between patients with avulsion (PB2) and without avulsion (PB0)

	PB-0 mean±SD	PB-0 mean±SEM	PB-2 mean±SD	PB-2 mean±SEM	NS
H movKeg pre	7.65±5.48	7.65±0.90	6.60±4.71	6.60±0.53	>0.05
H movKeg post	9.18±5.73	9.18±0.94	7.61±5.53	7.61±0.62	>0.05
D movKeg pre	-5.05±4.98	-5.05±0.82	-4.37±4.84	-4.37±0.54	>0.05
D movKeg post	-6.16±5.62	-6.16±0.92	-5.33±5.44	-5.33±0.61	>0.05
vector Keg pre	9.94±6.32	9.94±1.04	8.89±5.41	8.89±0.61	>0.05
vector Keg post	11.90±6.71	11.90±1.10	10.51±6.00	10.51±0.67	>0.05
ΔH	1.53±2.40	1.53±0.39	1.00±2.59	1.00±0.29	>0.05
ΔD	-1.11±2.08	-1.11±0.34	-0.97±2.39	-0.97±0.27	>0.05
Δvector	1.96±2.66	1.96±0.44	1.62±2.58	1.62±0.29	>0.05

Source: own elaboration.

Legend:

H moveKeg pre – parameter H of UM during PFMC before the training

H moveKeg post – parameter H of UM during PFMC after the training

D moveKeg pre – parameter D of UM during PFMC before the training

D moveKeg post – parameter D of UM during PFMC after the training

vector Keg pre – vector of UM during Kegel exercises before the training

vector Keg post – vector of UM movement during Kegel exercises after the training

ΔH – parameter H of UM after training minus parameter H before training

ΔD – parameter D of UM after training minus parameter D before training

Δvector – movement of UM after training minus vector movement of UM before training

Discussion

Non-operative treatment constitutes an important element of urogynecological therapy, aimed at both avoiding surgery and improving effects in patients after an operation. PFMT is recommended as an element of therapy in patients with SUI and POP. Sonography demonstrated that the bladder neck descent during PFMT on a cough stress test is significantly smaller than without pelvic floor muscle contraction. Thus, controlled urogenital diaphragm muscle contraction stabilizes the bladder neck location at increased intra-abdominal pressure [36]. Studies prove that urogenital diaphragm muscle contraction effectively prevents urine leakage in many women [36]. During pregnancy and after delivery, regular PFMT reduces the risk of SUI [8, 37, 38].

PFMT aims to alter the morphological structure of the urogenital diaphragm muscles by increasing their volume as well as increasing the number of active motor units and their activation frequency, hence increasing muscle tension. It should result in forming a reflex bringing about an automatic muscle contraction at increased pressure in the abdominal cavity. Effectiveness of performing PFMC depends, among others, on the correct technique applied [39, 40, 41]. Study showed that up to 30% of urogynecological patients cannot make PFMC of pelvic floor muscles [42]. Incorrectly performed exercises may lead to aggravated urogynecological complaints in the form of urinary incontinence and pelvic organ prolapse; however, many women, even after initial instruction, cannot contract their pelvic floor muscles properly [36, 43].

Women should be supervised by specialized personnel and encouraged to follow exercise rules [43]. Bø et al. showed that training guided by a skilled instructor is of great importance for exercise effectiveness as compared to training in a home setting. Studies demonstrated a huge difference in effects depending on the quality, intensity, and continuity of exercises, and small effects of training without strict supervision [7, 43].

It is the source of controversy which methods for testing, teaching, and supervising PFMC should be used. In the literature, we can find information about: verbal instruction, digital palpation, observation of perineal movement, manometers, and surface electromyography. Biofeedback equipment is often used in PFMT teaching. The biofeedback exercise technique allows visualizing mistakes and teaching patients how to effectively contract a specific muscle group. Special probes are placed in the vagina. Biofeedback exercises facilitate learning the conscious contractions of specific muscle groups while relaxing others. The aim is to improve reaction speed, contraction force ,and endurance of muscles, developing the potentials of fast and slow twitch fibers. An additional mobilizing element is the fact that the patient can assess the effects of the treatment itself (visual, auditory, sensory, verbal, pressure, and electromyographic biofeedback) [6, 7, 44, 45]. The probe used for biofeedback needs to be inserted into the vagina, what may have a potentially negative impact on the exercises. In pregnant patients, the probe or fingers should not be inserted into the vagina. Therefore, the ultrasound biofeedback performed introitally or transperineally – without introducing probe into the vagina – seems to be an attractive method for these patients. It may also be used in women with intact hymens or those with vaginismus and sexual dysfunction, where the availability of less invasive tools in the initial assessment helps to enhance their confidence and optimize therapy [5, 45]. Only a few studies analyzed the usefulness of the ultrasound biofeedback. They showed that it may be very helpful in learning PFMC. These works emphasize the potential usefulness of an ultrasound monitor for the visual biofeedback [6, 7]. Physicians commonly use pelvic floor ultrasound in their daily practice, and physiotherapists also use it more and more often. Ultrasound machines are widely available, the examination can be performed quickly and easily in an outpatient setting. The examination is non-invasive, enabling real-time imaging allows dynamic evaluation of changes occurring during functional testing. Pelvic floor ultrasound allows taking measurements with high repeatability and using them to check and compare the effects [7, 15, 25]. PFU-TA and PFS-TV were used to evaluate UM [15, 25]. There are no comparable studies between these two methods. In our study, PFS-TV was first used as ultrasound biofeedback. Our study showed that PFS-TV can be used for successful teaching of PFMC.

The LAM is important in maintaining various structures of the urogenital diaphragm. Damage to the LAM, which probably occurs in the 2nd stage of labor, during the descent of the fetal head, and has been reported in 13–36% of women giving birth vaginally, may have a negative impact on the pelvic floor muscles contraction strength and is a risk factor for POP. However, the impact of LAM avulsion on various functions, including UM, urinary and fecal continence, is not fully understood. The results of the studies obtained so far are ambiguous: some indicate the lack of influence of avulsion on the symptoms of SUI and fecal incontinence, others indicate an increased likelihood of these symptoms occurring in patients with avulsion [5, 27]. The influence of avulsion on learning PFMC has not been analyzed so far. Our study suggests that LAM avulsion does not influence the process of learning PFMC when PFS-TV is used as ultrasound biofeedback.

The Modified Oxford Scale is a common examination. It allows for easy evaluation of pelvic floor muscles without the need for additional tools [17]. It has been suggested that palpation and ultrasound examinations can assess different aspects of pelvic floor function. PFU-TA records the displacement of structures (bladder neck or different parts of urethra), while palpation assessed using the Modified Oxford Scale (MOS) measures muscle strength and endurance. Whether a given contraction force will result in greater or lesser displacement will depend largely on the stiffness or elasticity of the tissue. Therefore, the highly elastic tissues associated with POP can be strongly displaced with a relatively small force. On the other hand, much greater force may be needed for less displacement in women with excellent pelvic floor support and stiffer, less flexible tissues [5, 44, 45]. In our study, we showed that ultrasound biofeedback with the use of PFS-TV is useful in improving UM in women with different pre-training grades of ability to perform PFMC evaluated using MOS. Our results also suggest that PFS-TV biofeedback may be useful to improve PFMC (MOS).

The limitation of the study is the fact that the analyses were retrospective, the long-term effectiveness of PFMC learning and the long-term use of therapy by patients have not been analyzed. The advantages were the comprehensiveness of the assessment (three parameters of UM, MOS). Our study provides guidance on conducting further studies on ultrasound biofeedback. In the future, it would be interesting to evaluate the learning process in pregnant women using ultrasound biofeedback.

We concluded that PFS-TV can be useful in teaching PFMC. Avulsion and MOS grade seemed to have no influence on the learning effect of PFMC when ultrasound biofeedback was used. Evaluating UM during pelvic floor sonography using of the ultrasound parameters (H, D, and vector) can yield more comprehensive information than one parameter H.

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