Original Article

Can Pelvic Floor Muscle Training Positions be Selected According to the Functional Status of Pelvic Floor Muscles?

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Abstract

Background: Pelvic floor muscle (PFM) training varies according to the functional status of PFM. It is used to strengthen underactive PFM and relax overactive PFM. **Aim:** This study aimed to determine the appropriate PFM training positions according to the functional status of the PFM in women with pelvic floor dysfunction. **Materials and Methods:** Seventy-six women diagnosed with pelvic floor dysfunction were included. After the digital palpation, participants were divided into four groups according to the functional status of PFM: normal, overactive, underactive, and nonfunctional. Participants' PFM and abdominal muscle functions were assessed with superficial electromyography in three positions (modified butterfly pose-P1, modified child pose-P2, and modified deep squat with block pose-P3). Friedman's analysis of variance and the Kruskal–Wallis test were used to assess whether the function of the muscles differed according to the functional status of the PFM and training positions. **Results:** Normal PFM maximally contracted and relaxed in P1, whereas nonfunctional PFM was in P3 ($P > 0.05$). Overactive and underactive PFM was most contracted in P2 ($P > 0.05$) and relaxed in P1 ($P < 0.001$). In each functional state of the PFM, all abdominal muscles were most relaxed in P1, while their most contracted positions varied ($P < 0.05$). **Conclusion:** This study showed that the positions in which the PFM relaxes and contracts the most may vary according to the functional status of the PFM. Therefore, different PFM training positions may be preferred according to the functional status of the PFM in women with pelvic floor dysfunction. However, more study needs to be done in this subject.

Keywords: *Electromyography, pelvic floor muscle, pelvic floor muscle training, position*

Introduction

Pelvic floor dysfunction refers to a group of diseases, such as urinary or fecal incontinence, pelvic organ prolapse, sexual dysfunction, and chronic pelvic pain caused by abnormal pelvic floor muscles (PFM) function. PFM training is recommended as first-line therapy for the prevention and treatment of pelvic floor dysfunction. It is exercise practice performed to improve PFM strength, endurance, power, relaxation, or a combination of these parameters.[1] The functional states of PFM are divided into four: normal, overactive, underactive, and nonfunctional. Therefore, PFM training protocols vary according to the functional status of PFM. They are used to relax overactive PFM and strengthen underactive PFM.[2]

The lowest PFM activity was recorded in the supine position, and the highest activity was recorded while standing.[3] The highest PFM activity was observed in posterior pelvic tilt compared to anterior pelvic tilt and neutral. This is explained by the muscle's length–

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tension relationship.[4] Muscle fibers produce the greatest force when they are at an optimal length. The optimal muscle length is usually reached when it is close to its resting length. If the optimal muscle length is elongated or shortened, less force is produced.[5] However, some studies suggested that muscle activity is higher in the elongated position.[6-11] The position where PFM is the most elongated may be the position where they are maximally relaxed. Maximum strength increase can be achieved when PFM training is performed in the most relaxed position.

Body position and lumbopelvic posture can affect the effective contraction and relaxation of PFM and abdominal muscles and the co-contraction between these muscles.[3,4,12-15] Therefore, the idea that different PFM training positions should be performed according to the functional status of PFM stands out. Women with overactive PFM can perform training in positions where the PFM is most relaxed, and women with underactive PFM in positions where the PFM is most contracted. To the best of our knowledge, there is no study in the literature on this subject. Therefore, this study aimed to determine the appropriate PFM training positions according to the functional status of the PFM in women with pelvic floor dysfunction. Our other aim was to investigate the abdominal muscle function according to the functional status of the PFM and training positions.

Materials and Method

Study design and participants

This descriptive cross-sectional study included 76 women who applied to Dokuz Eylul University Faculty of Medicine, Department of Obstetrics and Gynecology and diagnosed with pelvic floor dysfunction.

Inclusion criteria: >18 years of age, women, diagnosed with pelvic floor dysfunction by gynecologist and physiotherapist, consent to participate in the study. Exclusion criteria: Pregnant women, women in the postpartum period, women in the menstruation period, women with active urinary system infection, women with a history of incontinence or abdominal surgery, and women with neurological, orthopedic, and psychiatric comorbidities.

Ethics statement

The study was conducted by the ethical standards of the Helsinki Declaration and was approved by Dokuz Eylül University the Institutional Non-invasive Research Ethics Board (Number: 4399-GOA). All the individuals gave written consent to participate in the study after receiving appropriate verbal and written information.

Assessments

The diagnosis of pelvic floor dysfunction was conducted by a comprehensive history and pelvic floor assessment. In addition, questionnaires were used to assess symptoms about urinary or fecal incontinence, pelvic organ prolapse, sexual dysfunction, and chronic pelvic pain.[16] Participants were assessed by three physiotherapists experienced in pelvic floor rehabilitation. The digital palpation was performed by the same physiotherapist, whereas superficial electromyography was performed by the other two physiotherapists.

Digital palpation

The digital palpation method was used to determine the functional status of PFM. The PFM tone was assessed by placing the index finger inside the vagina up to the proximal interphalangeal joint and applying a slow stretch at two different depths (superficial, deep) and three different sites (4, 6, 8 o'clock positions). According to the scale developed by Devreese *et al*., the PFM tone was classified as follows: "Normal: index finger can move subtly in the vagina, Hypertonic (overactive): vagina tightens as a firm band around the second phalanx of the index finger, Hypotonic (underactive): vagina ring is wide and very weak."[17,18]

PFM strength was assessed using the Modified Oxford Scale in all participants except women with hypertonic PFM. In the lithotomy position, the therapist inserts the index and middle fingers into the patient's vagina. The therapist asks the patient to contract PFM up and inward. PFM strength is graded as follows: "0: no contraction, 1: flicker contraction, 2: weak contraction, 3: moderate contraction, 4: good contraction, 5: strong contraction."[19] PFM strength was classified as follows: "5: normal, 2, 3, and 4: underactive, 0 and 1: nonfunctional." The participants were divided into four groups according to the functional status of PFM: normal, overactive (hypertonic), underactive (hypotonic), and nonfunctional.

Superficial electromyography (EMG)

Electromyographic activities of PFM and abdominal muscles were assessed using a superficial EMG device (NeuroTrac® MyoPlus 4 PRO, Verity Medical LTD., UK). The technical specifications of the device are as described in our previous study.[20]

PFM activity was assessed with a cylindrical endovaginal probe (Verity Medical LTD., UK) 8.7 cm long and 2.6 cm in diameter. After applying the anti-allergy gel, the probe's metal sensors were inserted into the vagina at 3-9 o'clock.[21] The activities of all abdominal muscles were assessed using disposable, superficial, self-adhesive, silver–silver chloride (Ag/Ag CI), and circular electrodes with a diameter of 3.2 cm. The skin area was cleaned with an alcohol swab to decrease skin impedance. Surface electrodes were placed on the abdominal muscles (Rectus abdominis—RA, transversus abdominis—TA, internal oblique muscles—IO, and external oblique muscles—EO) as described in our previous study.[20]

The participants were asked to empty bladders before the assessment. The correct contraction of PFM was taught to participants with digital palpation to prevent straining and contraction of different muscles.[3] The participants were asked to squeeze the therapist's fingers and pull in/upward as if holding urine or feces. An experienced physiotherapist warned participants during the measurement that when commanded to "relax," they should relax all PFM, and that when commanded to "contract," they should pull PFM in/up by squeezing as much as possible without contracting abdominal, and hip and thigh muscles, pulling in the abdomen, and holding the breath.

They were asked to perform maximum contraction for six seconds and relaxation for six seconds between the contractions.[12] Measurements were repeated three times in each position, and a minimum of two minutes rest intervals were given between positions to prevent muscle fatigue. After three measurements, the minimum, maximum, mean, standard deviation, MVC%, the onset of contraction, and relaxation were automatically recorded by the device. During the first measurements, a check measurement was taken that the electrodes were in the correct positions.

Positions

In physiotherapy clinics, the commonly recommended exercise positions for patients with pelvic floor dysfunction were investigated by pelvic floor physiotherapists through audiovisual media. Butterfly pose, child pose, and deep squat pose were chosen as positions that are widely recommended and familiar to most women. Physiotherapists and three different patients tried these positions. Positions were modified as some problems were revealed during the measurements that would affect the reliability of the data [Figure 1].

Modified butterfly pose (P1): In the supine position, a standard pillow was placed under the head and the arms were positioned next to the body. The hip joint was placed in flexion, abduction, external rotation, and knee joint flexion position. The tension of the adductor muscles was reduced with two pillows placed under the knees [Figure 1].

Modified child pose (P2): Although in the crawling position, it was positioned as leaning forward to receive support from the arms and sitting slightly backward with the hips. The contact of the participant's hips and feet was prevented in order not to create pressure on the electrodes and not to affect the electromyographic signals [Figure 1].

Modified deep squat with block pose (P3): The participant was positioned in the squatting position with knee level above the hip level. The participant was seated on two yoga blocks measuring 7.5 × 15 × 23 cm to maintain this position for a long time and to prevent possible movements from affecting the electromyographic signals [Figure 1].

Statistical analysis

The IBM® SPSS® Statistics 25.0 statistical program was used for statistical analysis. The normality of the data distribution was checked with Kolmogorov–Smirnov/Shapiro–Wilk tests. Among the descriptive statistics, continuous variables were expressed mean–standard deviation (minimum–maximum) and median (1st quartile–3rd quartile). The categorical variables were given as numbers and percentages. Kruskal–Wallis analysis and *post hoc* Mann–Whitney U test were used to determine whether PFM and abdominal muscle functions differed according to the functional status of PFM. Friedman's analysis of variance and post hoc Wilcoxon analysis with Bonferroni correction were used to determine whether PFM and abdominal muscle functions differed according to PFM training positions. The significance level was accepted as $P < 0.05$.

Results

Dokuz Eylül University Hospital records were scanned according to the codes of pelvic floor dysfunction for

Figure 1: P1: Modified Butterfly Pose, P2: Modified Child Pose, P3: Modified Deep Squat with Block Pose

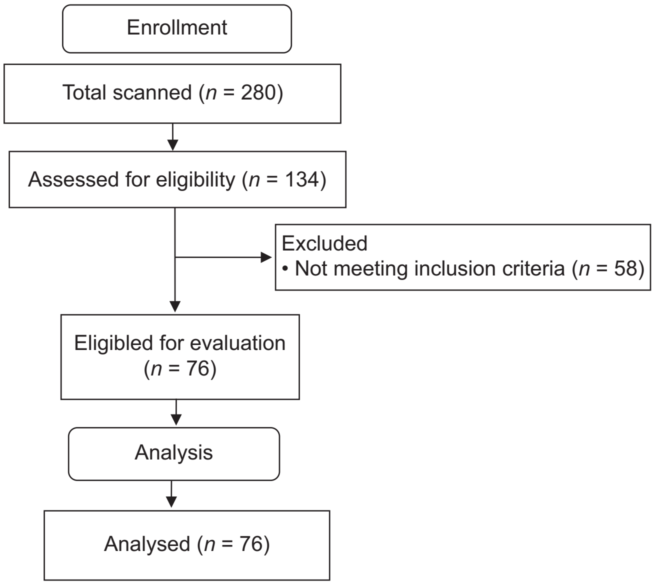

Figure 2: Flow Chart

the last three years, and a total of 280 individuals were reached. These individuals were contacted individually by telephone. 134 of the individuals agreed to participate in the study. 58 of the individuals contacted were excluded because they did not meet the inclusion criteria. Seventy-six participants completed the study and were included in the statistical analysis [Figure 2].

Demographic and obstetric/gynecological characteristics of the participants included in the study are given in Table 1. Considering the distribution of pelvic floor dysfunction, underactive PFM was 59.2%, normal PFM was 15.8%, overactive PFM was 13.2%, and nonfunctional PFM was 11.8%. None of the participants had a single pelvic floor dysfunction [Table 1].

Normal PFM maximally relaxed and contracted in P1 ($P > 0.05$). The most relaxation of overactive and underactive PFM was observed in P1 ($P < 0.001$),

Table 1: Demographic and obstetric/gynecological characteristics of the participants

Demographic characteristics	Min-Max	X±SD*/Median (IQR**)
Age (years)	29.0-66.0	52.1±7.5*
Body weight (kg)	62.0-98.0	78.7 (76.3-81.0)**
BMI (kg/m^2)	23.6-39.9	32.3 (30.2-32.3)**
Obstetric/gynecological characteristics	**Min-Max**	**X±SD**
Number of pregnancy (*n*)	2.0-6.0	3.2±1.3
Number of labor (*n*)	1.0-4.0	2.3±0.8
Number of abortion (*n*)	0.0-4.0	0.2±0.7
Number of children (*n*)	1.0-4.0	2.1±0.7
Age at first birth (year)	17.0-32.0	22.7±5.0
Birth weight of the baby (kg)	3.0-4.5	3.6±0.4
		***n* (%)**
Type of delivery	Vaginal	64 (84.2)
	Cesarean section	12 (15.8)
Dystocia	Yes	27 (35.6)
	No	49 (64.4)
Episiotomy	Yes	52 (68.4)
	No	24 (31.6)
Assistive device during labor	Yes	5 (6.6)
	No	71 (93.4)
Functional status of PFM	Normal PFM	12 (15.8)
	Hypertonic/overactive PFM	10 (13.2)
	Hypotonic/underactive PFM	45 (59.2)
	Nonfunctinal PFM	9 (11.8)
Pelvic floor dysfunctions	Urinary incontinence	56 (73.6)
	Fecal incontinence	16 (21.0)
	Constipation	23 (30.2)
	Pelvic organ prolapse	26 (34.2)
	Sexual dysfunction	34 (44.7)

*X±SD: Mean±Standard deviation, **IQR: Interquartile range, Min: Minimum, Max: Maximum, BMI: Body mass index, *n*: number, PFM: Pelvic floor muscles

Table 2: Comparison of PFM and abdominal muscles activity during relaxation and contraction according to the functional status of PFM and different training positions

	RA muscle activity during relaxation (MVC%) Position					RA muscle activity during contraction (MVC%) Position				
	P1 Median (IQR)	P2 Median (IQR)	P3 Median (IQR)	*P**	*P***	P1 Median (IQR)	P2 Median (IQR)	P3 Median (IQR)	*P**	*P***
Normal PFM (*n*=12)	13.8 (11.4-15.6)	20.0 (14.5-26.2)	15.2 (9.4-16.6)	0.029¥	P1:P2=0.010 P1:P3=0.638 P2:P3=0.016	34.4 (22.7-39.7)	31.0 (19.6-37.6)	24.5 (15.4-36.9)	0.234	
Overactive PFM (*n*=10)	15.6 (12.3-19.4)	22.3 (12.3-30.3)	16.2 (11.2-23.2)	0.169		33.6 (20.5-49.2)	32.8 (24.4-43.0)	24.9 (23.9-42.0)	0.368	
Underactive PFM (*n*=45)	14.8 (13.1-18.8)	22.1 (17.1-29.3)	16.3 (13.5-20.2)	0.000¥	P1:P2=0.000 P1:P3=0.146 P2:P3=0.000	29.9 (24.3-39.9)	29.4 (22.7-37.5)	23.4 (17.6-30.1)	0.000¥	P1:P2=0.582 P1:P3=0.000 P2:P3=0.001
Nonfunctional PFM (*n*=9)	14.1 (13.1-16.8)	27.5 (22.5-33.4)	15.7 (8.8-22.2)	0.066		29.3 (28.4-37.2)	34.7 (33.8-42.6)	21.6 (12.5-30.5)	0.276	
	*P**** 0.497	*P**** 0.391	*P**** 0.707			*P**** 0.836	*P**** 0.621	*P**** 0.509		
	TA muscle activity during relaxation (MVC%) Position					**TA muscle activity during contraction (MVC %) Position**				
	P1 Median (IQR)	**P2 Median (IQR)**	**P3 Median (IQR)**	***P****	***P*****	**P1 Median (IQR)**	**P2 Median (IQR)**	**P3 Median (IQR)**	***P****	***P*****
Normal PFM (*n*=12)	14.1 (9.6-22.9)	24.5 (22.4-31.2)	20.3 (13.2-21.1)	0.012¥	P1:P2=0.021 P1:P3=0.084 P2:P3=0.033	49.1 (41.5-55.0)	40.9 (36.3-50.9)	39.3 (33.0-52.2)	0.307	
Overactive PFM (*n*=10)	10.8 (9.2-24.4)	25.6 (19.1-29.9)	19.9 (16.3-26.7)	0.016¥	P1:P2=0.051 P1:P3=0.015 P2:P3=0.441	44.5 (38.2-56.3)	43.6 (37.5-49.6)	45.5 (40.4-50.6)	0.641	
Underactive PFM (*n*=45)	13.7 (9.2-20.8)	26.1 (18.9-33.4)	20.8 (15.5-25.0)	0.000¥	P1:P2=0.000 P1:P3=0.000 P2:P3=0.007	47.2 (39.8-53.8)	43.7 (35.9-50.5)	45.4 (31.7-52.3)	0.119	
Nonfunctional PFM (*n*=9)	15.5 (9.9-19.6)	31.5 (22.4-36.5)	23.8 (21.2-37.7)	0.066		44.9 (39.1-55.0)	47.2 (28.8-57.5)	51.8 (47.6-56.7)	0.368	
	*P**** 0.937	*P**** 0.883	*P**** 0.234			*P**** 0.975	*P**** 0.976	*P**** 0.113		
	IO muscle activity during relaxation (MVC%) Position					**IO muscle activity during contraction (MVC%) Position**				
	P1 Median (IQR)	**P2 Median (IQR)**	**P3 Median (IQR)**	***P****	***P*****	**P1 Median (IQR)**	**P2 Median (IQR)**	**P3 Median (IQR)**	***P****	***P*****
Normal PFM (*n*=12)	17.8 (14.1-21.0)	22.4 (17.6-32.0)	20.9 (14.5-24.8)	0.004¥	P1:P2=0.010 P1:P3=0.388 P2:P3=0.026	46.2 (41.7-56.5)	47.8 (38.5-50.1)	48.4 (36.3-55.7)	0.761	
Overactive PFM (*n*=10)	11.6 (9.8-20.4)	24.4 (22.6-27.9)	27.8 (12.6-32.0)	0.194		50.5 (37.2-57.3)	46.4 (44.1-50.9)	46.4 (43.6-56.3)	0.439	

Contd...

Table 2: Contd...

	RA muscle activity during relaxation (MVC%) Position					RA muscle activity during contraction (MVC%) Position				
	P1 Median (IQR)	P2 Median (IQR)	P3 Median (IQR)	*P**	*P***	P1 Median (IQR)	P2 Median (IQR)	P3 Median (IQR)	*P**	*P***
Underactive PFM (*n*=45)	14.3 (10.7-23.4)	27.1 (19.0-36.1)	22.2 (18.1-31.9)	0.000¥	P1:P2=0.000 P1:P3=0.000 P2:P3=0.009	50.7 (43.9-59.0)	48.8 (41.0-52.6)	49.8 (41.5-54.2)	0.262	
Nonfunctional PFM (*n*=9)	17.4 (9.2-20.6)	28.4 (25.0-30.5)	24.1 (17.1-27.3)	0.012¥	P1:P2=0.018 P1:P3=0.063 P2:P3=0.063	49.0 (32.2-50.2)	47.1 (35.6-57.6)	52.4 (32.7-55.5)	0.565	
	*P**** 0.587	*P**** 0.707	*P**** 0.701			*P**** 0.542	*P**** 0.880	*P**** 0.999		
	EO muscle activity during relaxation (MVC%) Position					EO muscle activity during contraction (MVC %) Position				
	P1 Median (IQR)	P2 Median (IQR)	P3 Median (IQR)	*P**	*P***	P1 Median (IQR)	P2 Median (IQR)	P3 Median (IQR)	*P**	*P***
Normal PFM (*n*=12)	11.4 (9.7-13.6)	15.9 (12.8-16.5)	11.6 (9.8-13.5)	0.009¥	P1:P2=0.004 P1:P3=0.237 P2:P3=0.008	19.7 (10.5-24.8)	17.9 (13.7-22.5)	14.2 (11.1-21.7)	0.513	
Overactive PFM (*n*=10)	11.5 (10.8-12.8)	17.5 (16.4-18.0)	12.9 (11.9-15.3)	0.003¥	P1:P2=0.008 P1:P3=0.374 P2:P3=0.011	13.7 (12.7-22.2)	23.1 (19.4-24.4)	19.7 (15.6-23.7)	0.097	
Underactive PFM (*n*=45)	11.5 (10.2-13.1)	16.4 (13.6-20.2)	13.1 (11.0-14.5)	0.000¥	P1:P2=0.000 P1:P3=0.004 P2:P3=0.000	13.5 (11.9-16.0)	17.9 (14.9-24.6)	14.7 (13.1-16.6)	0.000¥	P1:P2=0.000 P1:P3=0.003 P2:P3=0.001
Nonfunctional PFM (*n*=9)	9.9 (9.5-11.8)	16.3 (14.9-19.5)	11.4 (10.1-12.6)	0.007¥	P1:P2=0.018 P1:P3=0.090 P2:P3=0.046	11.6 (10.0-13.7)	17.9 (17.0-24.3)	13.2 (12.8-13.5)	0.022¥	P1:P2=0.028 P1:P3=0.063 P2:P3=0.043
	*P**** 0.412	*P**** 0.417	*P**** 0.119			*P**** 0.453	*P**** 0.293	*P**** 0.039		

*Friedman Variance Analyses, **Wilcoxon Test with Bonferroni correction, ***Kruskal–Wallis test and Mann–Whitney U, IQR: Interquartile Range, PFM: Pelvic Floor Muscles, RA: Rectus Abdominis, TA: Transversus Abdominis, IO: Internal Abdominal Oblique, EO: External Abdominal Oblique, P1: Modified Butterfly Pose, P2: Modified Child Pose, P2: Modified Deep Squat with Block Pose, ¥P<0.0

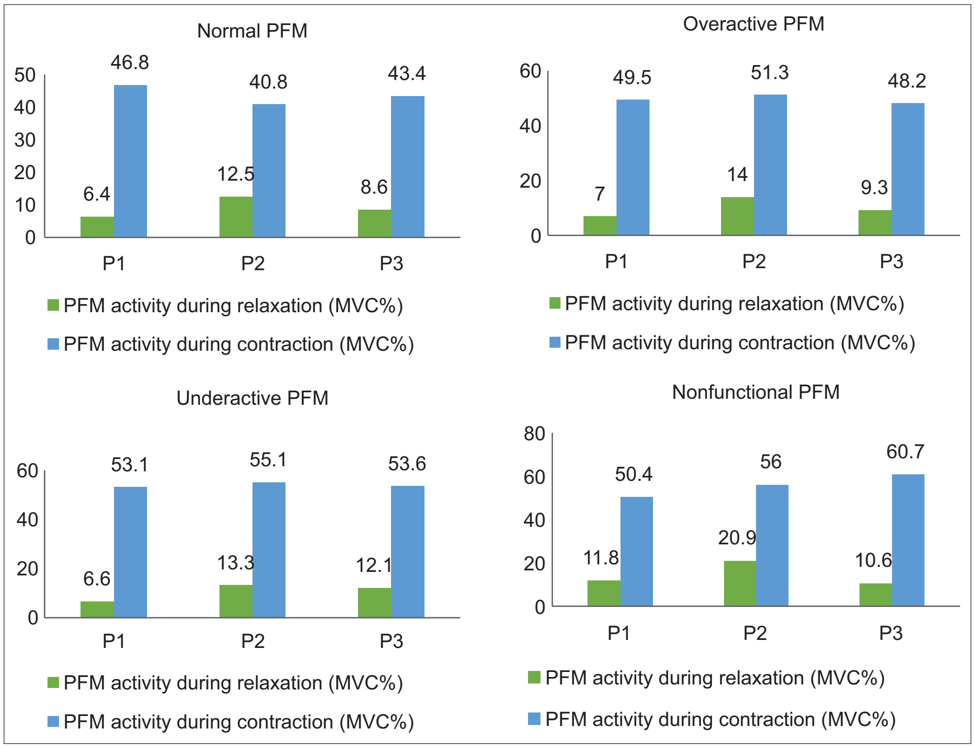

Figure 3: Contraction and relaxation activities of PFM according to three different training positions in different functional status of PFM, PFM: Pelvic Floor Muscles, MVC: Maximal Volunteer Contraction, P1: Modified Butterfly Pose, P2: Modified Child Pose, P3: Modified Deep Squat with Block Pose

whereas the most contraction was in P2 ($P > 0.05$). Nonfunctional PFM maximally contracted and relaxed in P3 ($P > 0.05$) [Figure 3].

During normal PFM relaxation, RA ($P = 0.029$), TA ($P = 0.012$), IO ($P = 0.004$), and EO ($P = 0.009$) muscles' lowest activities were found in P1. During normal PFM contraction, RA, TA, and EO muscles' highest activities occurred in P1, and IO muscle's highest activity in P3 ($P > 0.05$) [Table 2].

During overactive PFM relaxation, RA ($P > 0.05$), TA ($P = 0.012$), IO ($P > 0.05$), and EO ($P = 0.003$) muscles› lowest activities were observed in P1. During overactive PFM contraction, RA and IO muscle›s highest activities were in P1, whereas EO muscles were in P2 and TA muscles in P3 the highest ($P > 0.05$) [Table 2].

During underactive PFM relaxation, RA, TA, IO, and EO muscles' lowest activity was found in P1 ($P < 0.001$). During underactive PFM contraction, RA ($P < 0.001$) and EO ($P < 0.001$) muscles' activities were highest in P2, and TA and IO muscles' activities in P1 ($P > 0.05$) [Table 2].

During nonfunctional PFM relaxation, RA ($P > 0.05$), TA ($P > 0.05$), IO ($P = 0.012$) and EO ($P = 0.007$) muscles' lowest activities were in P1. During nonfunctional PFM contraction, RA ($P > 0.05$) and EO ($P = 0.022$) muscles' activities were highest in P2, whereas TA and IO muscles' activities were highest in P3 ($P > 0.05$) [Table 2].

Relaxation and contraction activities of PFM and abdominal muscles in all three different positions did not show a statistically significant difference according to the functional status of PFM ($P > 0.05$) [Table 2].

Discussion

This study showed that the training positions in which the PFM relaxes and contracts the most may vary according to the functional status of the PFM. Healthy (normal) PFM contracted maximally in the position where they were most relaxed. In other words, the PFM produced maximum contraction when it was most elongated. However, they produced maximum contraction in positions different from those where they were maximally relaxed in the case of pelvic floor dysfunction.

The modified butterfly pose is a position where normal PFM can maximally contract and relax. If PFM training is to be given to nonfunctional PFM, the most effective position may be the modified deep squat with block pose. Overactive and underactive PFM were maximally relaxed in the modified butterfly pose and maximally contracted in the modified child pose. Since it is emphasized that PFM training for relaxing should be given to women with overactive PFM, treatment can be started with the modified butterfly pose. The modified child pose may be recommended for strengthening underactive PFM.

In our study, PFM relaxed and contracted similarly in all functional states. In each functional status of PFM, all abdominal muscles were most relaxed in the modified butterfly position. Positional change and functional status of PFM may not affect the amount of co-contraction or the type of abdominal muscles that are most involved during co-contraction.

Studies suggested that a muscle may exhibit the highest activity in the elongated position.[5,9-11] Halski *et al*.[12] observed that the lowest resting activity and the highest functional activity of PFM occurred in the supine position. Therefore, they reported that the supine position is the most favorable position for relaxing and strengthening PFM. Similar to the literature, we found that normal PFM maximally relaxed and contracted in the modified butterfly pose. We think that this result may be due to the length–tension relationship of muscle. When a muscle is elongated, stimulation of muscle spindle (1a) afferents via stretch reflex can cause excitatory impulses to be carried into the motor neuron pool of the agonist's muscle.[22,23] When PFM is healthy, maximum contraction can occur in the most elongated position, thanks to neurophysiological mechanisms.

The maximal motor unit discharge rates of a muscle differ in a shortened or elongated position.[6-8] There is evidence that a shortened muscle receives more stimulation from the central nervous system.[24,25] Siff *et al*.[26] investigated the effects of 10 commonly used pilates positions on PFM in healthy women. They found that the levator hiatus area narrowed, the elongate of PFM was shortened, and muscle strength increased similar to kegel exercises in bird dog, plank, and leg lift positions. In these positions, they stated that the co-contraction mechanism between abdominal muscles and PFM could increase PFM contractions. In our study, it was found that overactive and underactive PFM maximally contracted in the modified child pose, whereas the maximally relaxed in the modified butterfly pose. When pelvic floor dysfunction occurs, PFM can maximally relax and contract in different positions. Similar to bird dog and plank positions, the modified child pose is performed in the crawling position. Therefore, the levator hiatus area may be narrowed and the elongation of PFM may be shortened in the modified child pose. In addition, the direct effect of the gravitational force on the anterior abdominal cavity may have caused stronger PFM contractions as a result of the co-contraction mechanism. In the supine position, performing the modified butterfly pose may result in gravitational force affecting the posterior of the abdominal cavity more than the pelvic floor, resulting in a decrease in PFM tone.[3] Higher activity has been observed in overactive PFM.[27] Therefore, since PFM training for relaxation should be given to overactive PFM, treatment can be started with the modified butterfly pose. The modified child pose can be recommended for strengthening underactive PFM.

Capson *et al*.[4] and Chmielewska *et al*.[3] found the highest resting activity of PFM in the unsupported sitting position compared to the supine position in continent women. They stated that gravitational force can increase PFM tone by causing pressure on the bladder and urethra in the vertical position.[3,4] In our study, we observed that nonfunctional PFM maximally contracted and relaxed in the modified deep squat with block pose. There is a greater need for tonic fibers of PFM activity during activities that require a great effort such as sitting.[28] Insufficient tonic activity in nonfunctional PFM may have caused decreased pelvic floor support and lowered pelvic floor in a modified deep squat with block pose. Therefore, elongating PFM can provide maximum contraction thanks to neurophysiological mechanisms. In addition, the direct effect of the gravitational force on the pelvic floor in this position may have increased the PFM tone. If PFM training is to be given to women with nonfunctional PFM, modified deep squat with block pose can be considered.

Studies reported a co-contraction mechanism between PFM and abdominal muscles.[3,4,12-15] Sapsford *et al*.[15] found the lower resting activity of PFM and abdominal muscles (EO and IO) in supported sitting compared to unsupported sitting positions. Chmielewska *et al*.[3] observed the lowest resting activity of PFM and abdominal muscles (RA and TA) in the supine position compared to sitting and standing positions. Similarly, we found that all abdominal muscles maximally relaxed in the modified butterfly pose in all functional states of PFM. Additionally, we observed that relaxation amounts of all abdominal muscles are the highest in the maximum relaxed position of PFM. Pelvic floor dysfunction did not affect the amount of relaxation of abdominal muscles. This result supports the continued co-contraction mechanism between PFM and abdominal muscles during relaxation. Therefore, the modified butterfly pose can be preferred when the PFM tone is increased or the co-contraction mechanism is desired to be reduced.

In our study, different amounts of co-contraction occurred in abdominal muscles in different training positions and functional status of PFM. In women with pelvic floor dysfunction, the co-contraction mechanism between PFM and abdominal muscles may be impaired.[29] When PFM is only healthy (normal), both abdominal muscles and PFM are maximally contracted and relaxed in the modified butterfly pose. However, pelvic floor dysfunction did not affect the amount of contraction and co-contraction of abdominal muscles in the same position. If it is desired to increase abdominal muscle activity during PFM training, protocols can be created according to the positions where these muscles contract most effectively. Further studies are needed to investigate this issue.

Our study has some limitations. Participants separated according to the functional status of PFM do not show a homogeneous distribution. Only three commonly recommended clinical positions were used for women with pelvic floor dysfunction. The results may not be applicable to female individuals under the age of 30 and over the age of 66.

Conclusion

This study showed that the training positions in which the PFM relaxes and contracts the most may vary according to the functional status of the PFM in women with pelvic floor dysfunction. Normal PFM maximally relaxed and contracted in the modified butterfly pose, whereas nonfunctional PFM was in the modified deep squat with block pose. Overactive and underactive PFM contracted most in the modified child pose and relaxed in the modified butterfly pose.

Ethical statement

This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by Dokuz Eylul University the Institutional Non-invasive Research Ethics Board (Number: 4399-GOA).

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Conflicts of interest

The authors declared no conflict of interest.

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