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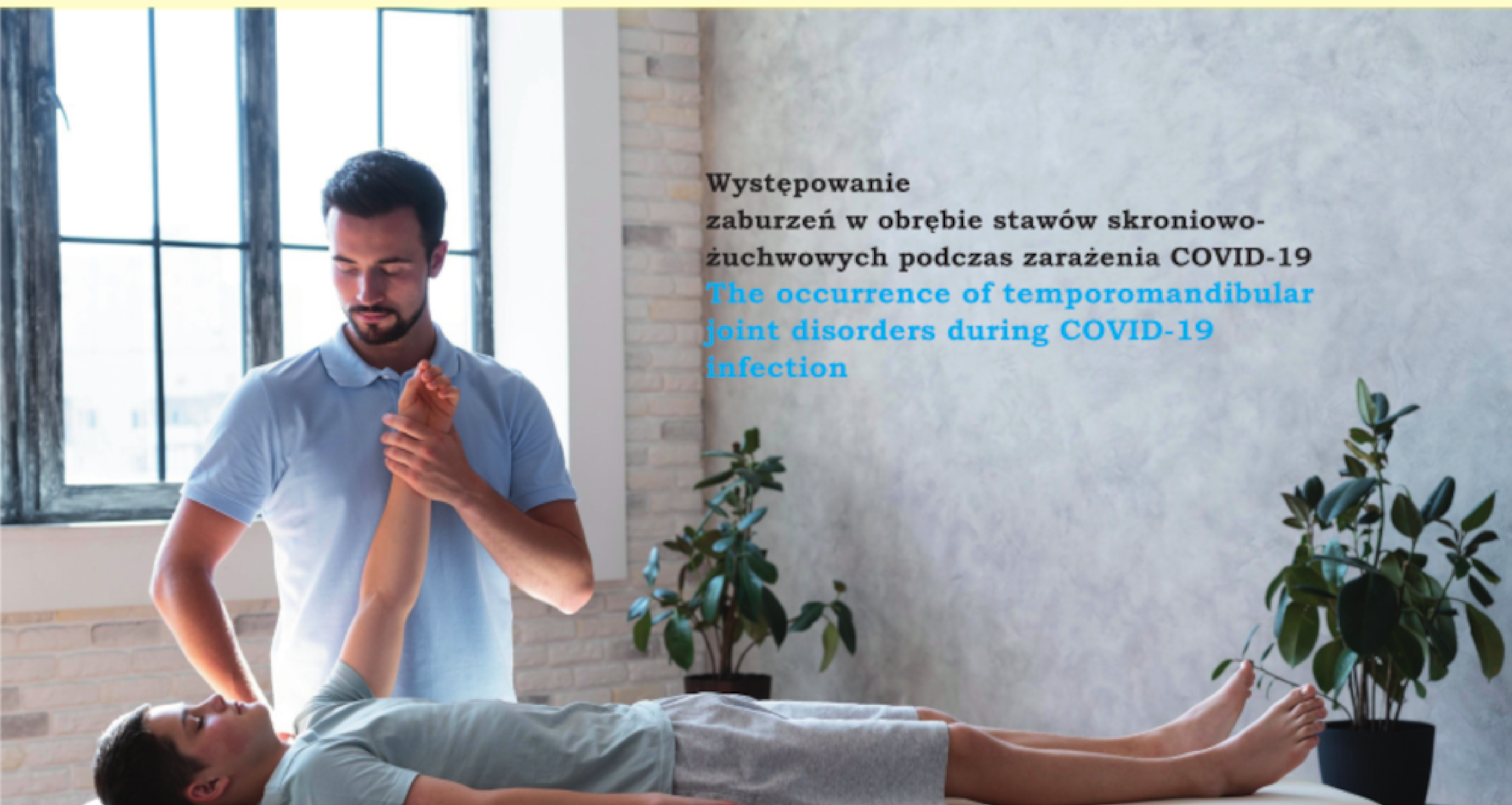

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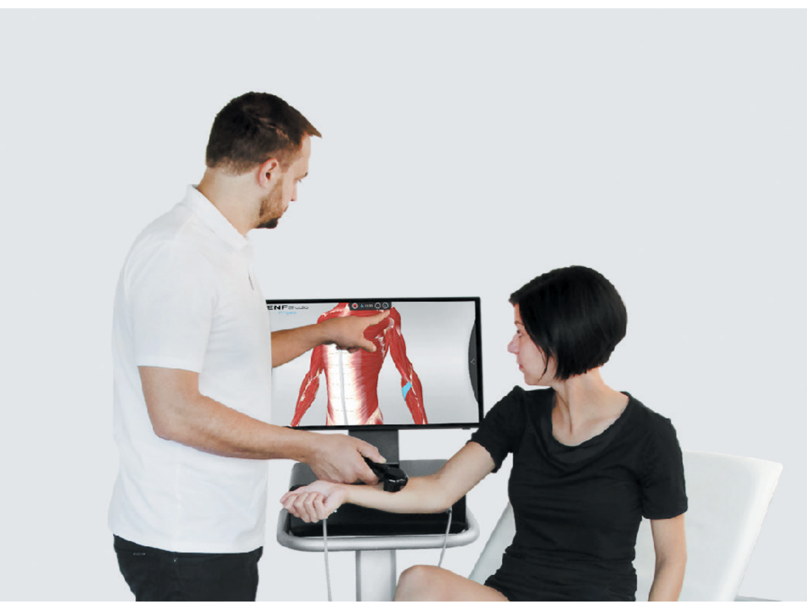

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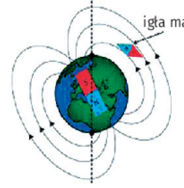

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Effect of pelvic floor and abdominal muscle training on diaphragmatic excursion in multigravida women

Oddziaływanie treningu mięśni dna miednicy i brzucha na ruchy przepony u kobiet wieloródek

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Abstract

Background. Several research studies have indicated that the diminished strength of the abdominal and pelvic floor muscles (PFM) affects the diaphragmatic function.
Objective. The study aimed to investigate the effect of a 12-week PFM and AbM training on diaphragmatic excursion (DE) in multigravida women.
Methods. Ninety multigravida women who were postpartum for at least 6 months after normal vaginal or cesarean delivery and between 30 and 45 years of age were randomly assigned to three groups of equal size (n = 30). Group (A) received abdominal and pelvic floor Kegel training. Group (B) received abdominal training. Group (C) received pelvic floor Kegel training. Ultrasonography was utilized to assess the effects of DE at three different time points: before training, immediately post-training, and at a 12-week follow-up after the end of training.
Results. The results showed that DE increased significantly in groups A (P = 0.038) and B (P = 0.009), with no significant differences in group C. Post hoc analysis revealed no significant differences between each group and the others, except for a significant difference between groups A and C (P = 0.001).
Conclusion. The concurrent implementation of 12-week AbM and PFM training is more effective in enhancing DE in multigravida women than solely engaging in either AbM or PFM training.

Keywords:

diaphragmatic excursion, rectus abdominous diastasis, pelvic floor muscle, ultrasonography, abdominal training, PFM training

Streszczenie

Wprowadzenie. Badania naukowe wykazują, że zmniejszona siła mięśni brzucha oraz mięśni dna miednicy (PFM) wpływa na funkcjonowanie przepony.
Cel. Celem badania było zbadanie wpływu 12-tygodniowego treningu PFM i mięśni brzucha (AbM) na ruchy przepony (DE) u wieloródek.
Metody. Dziewięćdziesiąt wieloródek, które były co najmniej 6 miesięcy po normalnym porodzie pochwowym lub cesarskim cięciu i które miały między 30 a 45 lat, zostało losowo przydzielonych do trzech równolicznych grup (n = 30). Grupa (A) przeszła trening mięśni brzucha oraz Kegla mięśni dna miednicy. Grupa (B) przeszła trening mięśni brzucha. Grupa (C) przeszła trening Kegla mięśni dna miednicy. Ultrasonografia została wykorzystana do oceny efektów DE w trzech różnych momentach: przed treningiem, bezpośrednio po treningu oraz w 12-tygodniowej obserwacji po zakończeniu treningu.
Wyniki. Wyniki pokazały, że DE znacząco wzrosło w grupach A (P = 0.038) oraz B (P = 0.009), bez istotnych różnic w grupie C. Analiza post hoc nie wykazała istotnych różnic między grupami, z wyjątkiem istotnej różnicy między grupami A i C (P = 0.001).
Wnioski. Jednoczesne wdrożenie 12-tygodniowego treningu AbM i PFM jest bardziej skuteczne w poprawie DE u kobiet wieloródek niż angażowanie się wyłącznie w trening AbM lub PFM.

Słowa kluczowe:

ruchy przepony, diastaza mięśni prostych brzucha, mięsień dna miednicy, ultrasonografia, trening brzucha, trening PFM

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Introduction

The abdominal-pelvic cavity encompasses a majority of internal organs and is demarcated by the diaphragm superiorly, the anterior and lateral abdominal muscles (AbM), the thoracolumbar fascia and dorsal muscles posteriorly, and the pelvic floor inferiorly. The abdomina-pelvic cavity is demarcated superiorly by the respiratory diaphragm, while the pelvic floor serves as its inferior boundary. As mentioned above, the structures are characterized by their concave-convex dome shape in opposite directions and are composed of striated muscle tissue in a compressed state between the fascia [1]. The diaphragm plays a crucial role in respiration and contributes to the stabilization of the trunk in conjunction with AbMs. Additionally, the activity of the PFMs may have an indirect impact on respiration. The PFM contraction is efficacious in facilitating the activation of the respiratory muscles and enhancing vital capacity. Therefore, it is recommended to consider utilizing the PFM as a means to enhance the outcomes of respiratory function[2]. Upon contraction of the AbMs, the diaphragm undergoes an upward movement, while the PFMs experience a downward movement. Elevation of intra-abdominal pressure (IAP) due to upward diaphragmatic movement triggers a contraction of the pelvic floor muscles (PFM) when the abdominal muscles (AbMs) are engaged with significant force.

Consequently, the PFM exhibits relaxation during the process of inspiration while simultaneously contracting to protect the internal organs in the event of a significant increase in IAP. During a forceful expiration, the PFM contracts causing an increase in IAP, resulting in the upward displacement of the diaphragm. Thus, it is imperative that the PFM assume the responsibility for responding to and managing fluctuations in the IAP in conjunction with the AbMs and diaphragm [3].

Throughout pregnancy, hormonal fluctuations resulting from the presence of relaxing progesterone and estrogen, in conjunction with the expansion of the uterus, can lead to the stretching of AbM, primarily affecting the rectus abdominis muscles. The anterior pelvic tilt, with or without lumbar hyperlordosis, is common during pregnancy. Alterations in posture have the potential to impact the insertion angle of the pelvic muscle and AbMs, thereby exerting an influence on postural biomechanics. Additionally, they can potentially create a deficiency in support of the pelvic-abdominal organs. Furthermore, during pregnancy, AbMs undergo stretching, resulting in a reduction in their force vector and a potential decline in their ability to contract with full strength. AbM weakness is frequently observed in women who undergo multiple pregnancies, which can lead to the accumulation of mechanical stress on the connective tissue of the abdominal wall, resulting in recurrent muscle stretching [4]. Currently, as lifestyle and pollution directly impact the respiratory system, even for normal individuals, there is a growing demand to prioritize the independence of multigravida women, minimize disabilities, and enhance their functional status to improve their quality of life. Therefore, our objective was to investigate the effect of PFM and AbMs training on the diaphragmatic excursion (DE) in multigravida women to determine the overall improvement in their general activity.

Material and methods

Participants

Between March 2021 and April 2023, this randomized controlled trial (RCT) study was performed. The objectives of the study and the potential risks were communicated to all participants. All study participants signed a consent form. The Ethics Committee of the Physical Therapy Faculty of Cairo University has granted approval for this study. (No. P.T.REC/012/003157).

Ninety adult women were selected from the outpatient clinic of El Galaa Teaching Hospital in Egypt. They were referred by gynecologists and obstetricians. Their ages ranged from 30 to 45 years, their body mass index (BMI) was 25-35 kg/m^2, and their waist circumference (WC) was $\geq$ 80cm. All participants were multigravida women who had given birth 2-4 times, either cesarean or normal delivery. The AbM strength was assessed using the manual muscle test and graded as 2+. Meanwhile, PFM strength was evaluated using the modified Oxford grading system and graded as 2+. The postpartum period was at least 6 months. Participants who had urinary tract infection, uterine prolapse, pelvic tumor, chronic chest disease, smoking, diabetes mellitus, heart or lung disease, a musculoskeletal disease that could affect exercise, neurological diseases, and patients with hepatosplenomegaly, ascites, colon distention, hernia, and pregnancy were excluded.

Procedures

All participants were subjected to a physical assessment by a qualified physiotherapist and physician at the beginning of the trial to determine their eligibility for participation. A survey was utilized for gathering demographic data. Each participant's height (cm) and weight (kg) were noted, and BMI was determined.

The randomization process was performed using closed envelopes, ensuring that each participant had an equal chance of being allocated to any of the three groups. A blinded researcher observed the envelopes and assigned the participants according to their groups.

Outcome measures

Diaphragmatic sonography

DE was measured using ultrasonography for all three groups before and after the intervention. Before each examination, all subjects were asked to lie in a semi-recumbent position with a bed slope of 45 degrees and to rest and breathe quietly. Each subject was instructed to inhale deeply and exhale as quickly and deeply as possible, reaching their maximum inspiratory capacity. The diaphragm was scanned using ultrasonic examination in maximum inspiration and expiration through the anterior abdominal wall under the costal margin. On the right side of the diaphragm, two sweeps of the transducer were performed: one during maximum inspiration and the other during maximum expiration. The transducer was placed on the anterior subcostal abdominal wall in the midclavicular line [5].

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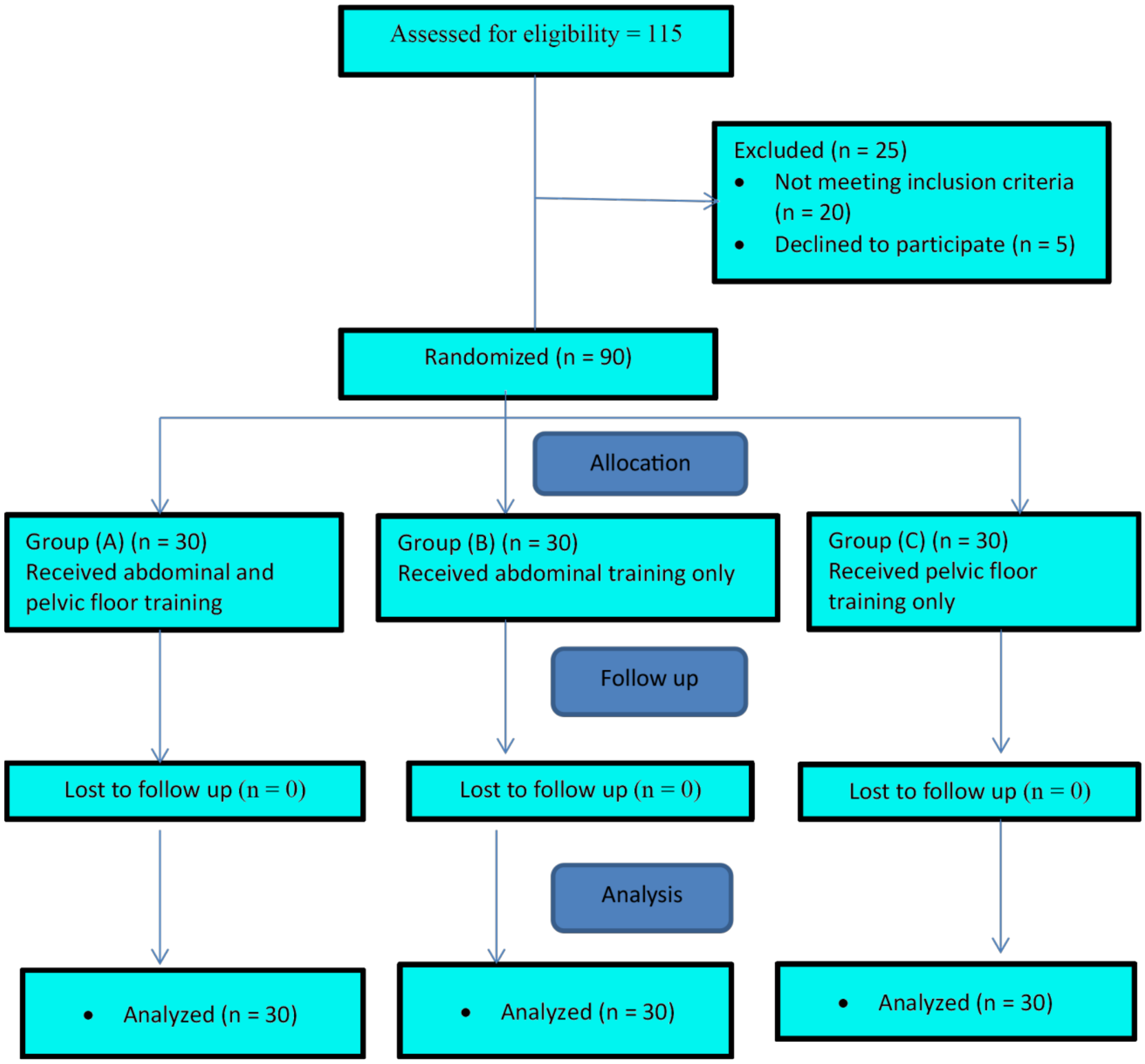

Figure 1. A flowchart that illustrates the selection criteria

Baseline assessment

First, BMI was calculated using weight/height scale measurements with the sole purpose of verifying the level of obesity in patients. Moreover, the WC of the participants was determined using a tape measure. The muscle test was utilized as a means of assessing the strength of the AbM. Additionally, the revised Oxford grading system has been proposed as a means of assessing the PFM strength.

Interventions

Group (A): The study group received abdominal and pelvic floor training. The abdominal training program involved 30 min/sessions with 3 sessions/week/12 weeks. It included 4 sets of dynamic abdominal exercises with 30 repetitions and 5 sets of static abdominal exercises with a persistence of 10 seconds. In addition, the subjects performed pelvic floor Kegel exercises. The aforementioned exercises were performed in a repeated manner for a total of 10 iterations, thrice a day (during the morning, afternoon, and night) over a period of 12 consecutive weeks.

Group (B): The group designated as the control group underwent abdominal training. The abdominal exercise regimen comprised three weekly sessions, each lasting 30 minutes, over a period of 12 weeks. The routine comprised four rounds of dynamic abdominal exercises, each consisting of 30 repetitions, and five rounds of static abdominal exercises, each held for a duration of 10 seconds [6,7].

Group (C): The control group received pelvic floor Kegel training. The training program involved performing pelvic floor Kegel exercises. These exercises were repeated 10 times, 3 times/day (morning, afternoon, and night)/12 successive weeks [8].

The intervention was performed in a secluded and protected area in the hospital outpatient clinic (see the Appendix for details).

Statistical analysis

All statistical measures were performed using the Statistical Package for Social science (SPSS) program version 25 for windows. Testing of normality using the Shapiro-Wilk test was used, reflecting that the data were normally distributed and allowed for conducting parametric analysis for all measured dependent variables. Additionally, testing for the homogeneity of covariance revealed no significant difference with p values of > 0.05. So, a 3×2 mixed design ANOVA was used to compare the tested variables at different tested groups and measuring periods, with α level was set at 0.05.

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Results

Typically, 90 females were allocated randomly into 3 equal groups. Table 1 revealed no significant difference in the participants' characteristics, including age, BMI, and WC (P = 0.249, 0.118, and 0.132, respectively). The study found a significant increase in DE between groups A and B following their training, with a respective percentage of changes of 10.3% and 8.4% and a P value of 0.009 and 0.038, respectively. On the contrary, group C did not show a significant change in DE (P = 0.078) with a percentage of change of 8.8%.

Table 1. Basic characteristics of the participants.

	Group A Mean ± SD	Group B Mean ± SD	Group C Mean ± SD	p-value
Age (years)	38.8 ± 6.8	37.7 ± 4.6	40.5 ± 7.3	0.249
BMI (kg/m²)	29.6.3 ± 5.3	31.7 ± 5	32.4 ± 5.5	0.118
WC (cm)	98.17 ± 12.17	102.35 ± 11.9	96.62 ± 9.46	0.132

Table 2. Multiple pairwise comparisons for the outcomes among and within the three tested groups.

	Group A Mean ± SD	Group B Mean ± SD	Group C Mean ± SD
Pre-training	2.63 ± 0.85	2.39 ± 0.58	2.04 ± 0.46
Post- training	2.9 ± 0.96	2.59 ± 0.61	2.22 ± 0.43
Change%	10.3%	8.4%	8.8%
Comparison within Group	P = 0.009*	P = 0.038*	P = 0.078
Post hoc tests			
Groups	**P-value**		
Groups A vs. B	0.111		
Groups A vs. C	0.001*		
Groups B vs. C	0.158		

Discussion

The present investigation revealed a significant enhancement in DE following a 12-week intervention in both the combined group (abdominal and pelvic floor training) and the abdominal training group. In contrast, the pelvic floor (PF) group exhibited no significant improvement in DE. Therefore, our results indicated that the combination of abdominal and pelvic floor training, as well as abdominal training alone, seems to be more beneficial than pelvic floor training alone in improving DE.

Our results agree with Kamel et al. [9], who posited that the perception of PFM contraction varies between individuals and may require the implementation of various techniques. The observed enhancement in the abdominal and combined groups can be attributed to the indirect activation of the PFMs through the AbMs, which facilitates the maintenance of their coordination, support, endurance, and strength. Furthermore, our findings are consistent with the assertion made by Zachovajeviene et al. [10] regarding the crucial function of the pelvic floor in facilitating coordination between the diaphragm and AbMs to maintain intra-abdominal pressure.

Contrary to the present result, a study has performed PFM strength using electrical stimulation and reported a significant improvement in DE during tidal (P = .002) and forceful breathing (P = .005) and coughing (P < .001) when comparing the results before and post-training results in the PFES group [12]. This discrepancy could be attributed to the focus effect of the electrical stimulation on the muscles.

The current investigation exhibits several constraints that warrant contemplation. Initially, it should be noted that the investigation only comprised multigravida women, which constrains the applicability of the results to other demographic groups. Second,

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the study had a relatively small sample size, which could restrict the statistical power to identify significant differences. Finally, the study did not follow up with the participants after the intervention, which limits our understanding of the long-term effects of the intervention.

Conclusions

In conclusion, our research provides strong evidence that a combined or integrated strategy involving PFM exercises and AbMs exercises is highly advantageous in enhancing diaphragmatic function among multigravida women.

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Appendix

Stage	Exercise prescription
Abdominal exercise for groups (A and B) [6, 7]	**1. Dynamic strength of AbM** For each exercise, two sets of 15 repetitions were performed, separated by a rest of 5 min. Each repetition consists of 10 s contractions followed by 20 s relaxation. **Straight Curl-ups:** In the crook-lying position, subjects were instructed to contract their AbMs forcefully and statically and then try to straight sit-up. **Double knee to chest:** In the crook-lying position, subjects were instructed to contract their AbMs forcefully and statically before attempting to bring their knee to their chest. **Diagonal Curl-ups to the right and to the left:** In the crook-lying position, subjects were instructed to contract their AbMs forcefully and statically and then try oblique sit-up to the right and the same to the left **2. Static strength of AbM** The subjects were asked to perform static abdominal10 seconds and repeat it 5 times at different positions as ((a) Draw-in (on all fours), (b) Draw-in (prone), (c) Halfplank, (d) Side-plank, (e) Oblique sit-up, (f) Straight sit-up) After completing the repetitions, they were given a rest period of 1 minute a The participant was instructed to assume one of the following positions based on her comfort and condition: crook lying position, quadruped position, side-lying position, or sitting position, then contract her PFMs, specifically focusing on the pubovaginalis, puborectalis, and pubococcygeus muscles, making sure not to tighten the stomach, thigh, buttock, or chest muscles.
Pelvic floor exercise for groups (A and C) [8,11]	**The first step for pubovaginalis:** Subjects were instructed to contract the anterior fibers of pubococcygeus for 15 repetitions of 10 s contraction and squeezing followed by 20 s relaxation. After 15 repetitions, patients rested for 5 min. Movement of the perineum (as holding micturition) **The second step for puborectalis:** Subjects were instructed to contract the posterior fibers of pubococcygeus for 15 repetitions of 10 s contraction and squeezing followed by 20 s relaxation. After 15 repetitions, patients rested for 5 min. The therapist's fingertips applied pressure to the area surrounding the anus in order to elicit contraction of the puborectalis muscle and identify any substitution of the gluteus Maximus muscles (as holding deification) **The third step for pubococcygeus as a whole:** Subjects were instructed to contract the anterior and posterior fibers of pubococcygeus for 15 repetitions of 10 s contraction and squeezing followed by 20 s relaxation. In Step 2, palpation was performed along with verbal guidance to facilitate elevation of the perineum.

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