RESEARCH PAPER

Effect Of Pelvic Floor Muscle Training On Dynamic Postural Stability In Postmenopausal Females With Stress Urinary Incontinence: A Randomized Controlled Trial

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Abstract

Background: The relationship between stress urinary incontinence (SUI), as a one of pelvic floor disorders (PFDs), with balance deficits and high injury prevalence during menopause has been revealed by studies. This fact suggested the role pelvic floor muscle (PFM) strength on dynamic postural stability in postmenopausal females.

Aim: The current study aim was to investigate the effect of pelvic floor muscle training (PFMT) on dynamic postural stability in postmenopausal females with SUI.

Sample: Consisted of 30 postmenopausal females with SUI, recruited from Woman Health Outpatient Clinic, faculty of physical therapy, Deraya university, they were randomly divided into two groups: the study A (n= 15) and control B (n= 15) groups, their body mass index (BMI) was less than 30kg/m^2 and their ages range was from 50 -60 years.

Material and methods: Group A engaged in PFMT in addition to traditional physical and balance training program three sessions/ week for twelve weeks. Group B engaged in traditional physical and balance training program only, three sessions/ week for twelve weeks. International Consultation on Incontinence Questionnaire (ICIQ-UI SF) was used for assessment of severity of urinary symptoms; PFM strength was assessed through measuring bladder base elevation by ultrasonography. Dynamic postural stability was assessed through Biodex Balance system. Measurements were taken at the beginning and at the end of intervention period.

Results: ICIQ-UI SF score significantly decreased, and bladder base elevation significantly increased in group A without any significant difference in group B posttreatment. Both groups showed significant decrease in all stability and sway indices, however, Group A showed significant decrease in all parameters compared to Group B ($P<0.05$).

Conclusion: The combination between PFMT and traditional balance training proved to be an effective intervention in improving the PFM strength, symptoms of SUI and significantly improving dynamic balance performance in postmenopausal females.

Keywords: Pelvic floor muscle training, Stress urinary incontinence, Postural stability, postmenopausal females.

How to cite this article: Hager M. AbdelAziz, Khadyga S. AbdelAziz, AbdelRahman H. AbdelWahab, Afaf M. Botla, Omar M. Mabrouk, Anan A. Anter, ; Effect Of Pelvic Floor Muscle Training On Dynamic Postural Stability In Postmenopausal Females With Stress Urinary Incontinence: A Randomized Controlled Trial..Int J Drug Deliv Technol. 2026;16(4s): 59-65 DOI: 10.25258/ijddt.16.59-65

Source of support: Nil.

Conflict of interest: None

Introduction:

Surrounding the urethra, vagina, and anus, a dome-shaped muscles and fascia called pelvic floor muscle (PFM) [1]. Proper contraction and relaxation of PFM maintain pelvic organs stability and participate in urinary and fecal continence, sexual functions, and childbirth [2].

PFMs are a part of the trunk stability mechanism with other muscles, that help to stabilize the pelvis, spine, and extremities during activities. Any synchronic disturbance of these muscles will result in pressure changes and subsequently postural stability dysfunction [3, 4].

Studies found that in comparing to women without UI, women with UI have impaired activities of daily living (ADLs) performance and mobility, which lead to impaired balance and a higher risk of falls [5].

Clinical studies demonstrated PFMT effect in the treatment of UI as it enhances muscle strength and neuromuscular control, enabling PFMs to function with more power and coordination. This coordination is crucial in SUI, an involuntary loss of urine during intra-abdominal pressure increase, where the activation timing and strength of PFM should counterbalance intra-abdominal pressure increases [6]. Studies concluded that there is relationship between PFM strength and postural stability in middle-aged females also, identified a greater center of pressure COP displacement in women with UI [7, 8, 9].

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Studies systematic reviews pointed to the need for research that concentrates on the interventions that reduce the risk of falls in terms of injury prevention and decrease morbidity and mortality rate among postmenopausal females. The effect of PFMT on balance performance in the older females has not been clearly supported so far [10]. So, the aim of this study was to identify the effect of PFMT on dynamic postural stability in postmenopausal females with SUI.

Participants and Methods

Study Design:

This study was designed as randomized controlled trial (RCT), It was registered at clinical trial.gov. (NCT06738147) and approved by the Ethical Research Committee, Faculty of Physical Therapy, Cairo University (No: P.T.REC/012/005377). This study followed the guidelines of Declaration of Helsinki on the conduct of human research. The practical aspect carried out from December 2024 – September 2025.

Sample size estimation:

The size of the research sample was calculated from (dynamic balance) as a primary outcome depending on the data from published research [11]**,** the minimal sample size was 24 for both groups, and the number increased by 25% to accommodate for dropouts. Total proper sample size was 30 subjects for both groups.

Participants:

Of the initial 36 participants, two of them refused participation in the study for personal reasons, other four didn't follow the inclusion criteria. So, only thirty postmenopausal females participated in this study, recruited from Woman Health Outpatient Clinic, Faculty of Physical Therapy, Deraya University, randomly assigned in two groups study (A) and control (B) group, each group had (15) postmenopausal female, the computerized block randomization procedure was used. The initial purpose of the study was explained, then each female has received and signed an informed consent.

Eligibility criteria:

Nonathletic, postmenopausal females suffering from moderate to severe SUI (score >9 at ICIQ-SF) and balance disorders. Their ages ranged from 50-60 years old; BMI was less than 30 kg/m^2. All females were able to walk across a small room without an assistive device. Exclusion criteria are, history of lower extremity pain during ADL, injury or surgery, history of brain injury, neurological diseases, inner ear problems that may affect balance or significant visual and hearing damage, cognitive deficits, internal orthopedic or oncological diseases [9, 10] **(Fig. 1).**

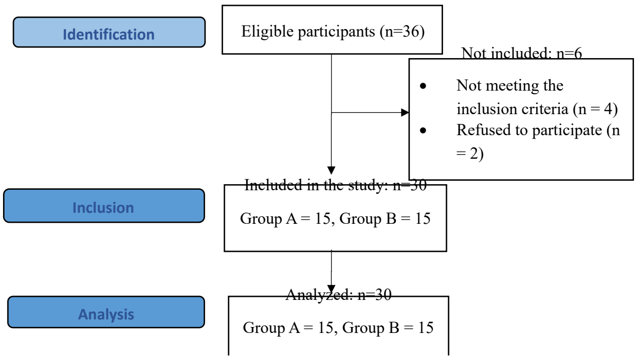


Fig. (1): Strobe flow chart of the study.

Outcome measures:

Evaluation of all females in both groups was carried out at the study beginning and after the treatment period, for severity of SUI through (ICIQ-UI SF), bladder base elevation as an indicator for PFM contraction through ultrasonography, and dynamic balance performance through the Biodex balance system (BBS). The evaluation was carried out by specialists who were blinded to study intervention and the group assignments.

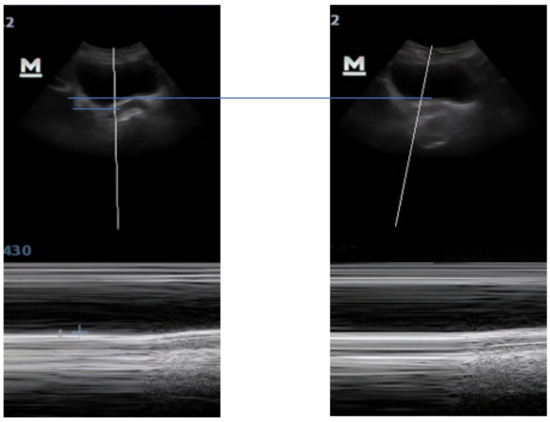
Severity of SUI:

SUI's severity was assessed through the Arabic version of ICIQ-UI SF that is considered reliable, valid, stable and clear method for assessing the UI symptoms and their quality-of-life impact in clinical practice (Cronbach's alpha coefficient of 0.97 (95% CI: 0.88-0.98)). The scores range from (0-21), with four sub-categories: slight (1-5), moderate (6-12), severe (13-18) and very severe (19-21) [12-13].

Bladder base displacement:

Transabdominal ultrasonography (TAU) using Ultrasound imaging device (Mindary DP10, bn-75013216, China), a reliable method to measure the bladder base displacement during PFM contraction [ICC = 0.85, 95% CI = (0.72, 0.96)] [14]. The TAU image of a PFM contraction causes a vertical displacement of the bladder base, representing a cephalic PFM movement [15-16].

The ultrasound evaluation protocol included: before the assessment by 1 hour, females were asked to empty the bladder, then drinking 0.5 L of water. Participants were trained to correctly perform PFM contraction, then lay in a crook lying position and TAU probe was placed on the midsagittal plane of the suprapubic area. For clearer imaging of the inferior-posterior aspect of the bladder, the transducer was placed with an angle of (60 degrees) in the inferior-posterior direction. The participants performed three maximal PFM contractions to measure posterior bladder wall displacement. At the junction of the hyper- and hypoechoic area of the bladder base, a marker was placed at the spot of maximum displacement detected during PFM contraction. The difference in bladder base displacement between the resting position and the end of each maneuver was measured in millimeters **(Fig. 2)** [17-18].



A: Before treatment B: After treatment

Fig. (2): Bladder base elevation measurement

Dynamic postural stability

Biodex Medical Systems (Inc., Shirley, NY, USA) which utilizes a computer software (Biodex, Version 3.1, Biodex Medical Systems) provides a valid, reliable objective measurements of postural stability on different surface conditions (static or dynamic), and the balance assessment produces stability and sway indices that considered reliable and valid when measured by a single specialist (ICC (OSI = 0.85, APSI = 0.78, MLSI = 0.84)) [19-20].

Participants completed a dynamic postural stability test while the subject was standing on foot-platform barefoot with, foot angle and heel position were recorded according to the grid coordinates on the device's platform, instructed to maintain the platform stable, arms relaxed and looking straight until all trials were completed, using 20-second trials at stability levels 12–6, with one practice and three test trials separated by 10-second rests, then the average was calculated [21], [22]. Three stability indices were calculated, antero-posterior stability index (APSI), mediolateral stability index (MLSI) and overall stability index (OSI), that represents subject's angular excursion of the COG at the sagittal plane, frontal plane and in all motions and directions respectively. Also, three sway indices were calculated, antero-posterior sway index, Mediolateral sway index and overall sway index, represents postural sway at the sagittal plane, frontal plane and in all motions and directions respectively. The higher these indices, the more the individual is unsteady [21].

Intervention:

Proprioception and balance training

Every participant in both groups engaged in traditional proprioception training and balance exercises program 30 minutes per training session, three sessions/ week for 12 weeks that included: standing position with legs opened at pelvis width, standing position in narrow base, standing on balance board with a wide base, then narrow base, standing on one limb, all conditions with open eyes, then closed eyes. Then followed by gait training including forward walking, side walking, backward walking, tandem walking, walking on an inclined surface and walking over obstacles [10,23].

PFMT program:

Every participant in the study group engaged in PFMT, 30 minutes per training session, three sessions/ week for 12 weeks that included: 1- Education about anatomy, physiology, and function of PFM, 2- PFMT in various positions (crock lying, sitting and standing) in the 1st month, and 3- PFMT with dual cognitive tasks (PFMT—DT) from the 2nd and 3rd months. Each female was shown how to do correct Kegel exercises while lying in crock position, which required contracting PFM for a few seconds then relaxing. Kegel exercises started with identifying the muscles and the right contraction, followed by slow and fast contractions. Slow contractions: participants were required to lift the PFM then hold the muscles (10 seconds and relax for 10 seconds), doing three sets of ten contractions with a two-minute break in between. Fast contraction: participants performed six sets of PFM exercises a day, each set including 10 fast (1 s duration) contractions with an equal rest time. All females were told to avoid holding their breath or strain, relaxing their abdominals and gluteal muscles during PFM contractions [24-25]. 4- Behavioral training (one time at the beginning of treatment period) includes instructions about Fluid intake, Diet and Voiding habits. 5- Home PFMT exercises were provided and the aim was to increase the total PFM contractions to 300 per day [10]. All training sessions were conducted by the same therapist at the Women's Health clinic, Deraya University.

Statistical analysis

Subject characteristics comparison between groups was conducted by Unpaired t-test. Data normal distribution was tested by Shapiro-Wilk test. Homogeneity between groups was tested with Levene's test for homogeneity of variances. To compare within and between groups effects on ICIQ-UI SF, bladder base elevation, stability and sway index, two-way mixed MANOVA was used. Post-hoc tests using the Bonferroni correction were carried out for subsequent multiple comparisons. The level of significance for all statistical tests was set at $p < 0.05$. All statistical analysis was conducted through the statistical package for social studies (SPSS) version 25 for windows (IBM SPSS, Chicago, IL, USA).

RESULTS

- Subject characteristics:

Table (1) shows that there was no significant difference between group A and B in subject characteristics (age, height, weight and BMI) ($p > 0.05$).

Table 1. Subject characteristics of group A and B:

	Group A	Group B		
	Mean ±SD	**Mean ±SD**	**t-value**	**p-value**
Age (years)	55.33 ± 3.44	56.93 ± 2.52	-1.45	0.16
Weight (kg)	75.57 ± 3.02	75.73 ± 2.49	-0.17	0.87

Height (cm)	159.47 ± 2.33	159.20 ± 2.27	0.32	0.75
BMI (kg/m²)	29.71 ± 0.66	29.88 ± 0.52	-0.78	0.13

SD, Standard deviation; p value, Probability value

Effect of treatment on ICIQ-UI SF, bladder base elevation, stability index and sway index:

According to two-way mixed MANOVA, a significant interaction of treatment and time (F = 76.59, p = 0.001, ηp² = 0.97), a significant main effect of time (F = 137.41, p = 0.001, ηp²= 0.98) and a significant main effect of treatment (F = 20.64, p = 0.001, ηp² = 0.88) were detected.

Within group comparison

There was a significant decrease in ICIQ-UI SF and a significant increase in bladder base elevation in group A (p < 0.001) while group B showed no significant change (p > 0.05) (Table 2).

All stability as well as sway indices were significantly reduced post treatment in both group A (p < 0.001) and group B (p < 0.001). (Table 3 and 4).

Between group comparison

Post treatment comparison between groups showed a significant decrease in ICIQ-UI SF (ES = 2.30) and a significant increase in bladder base elevation (ES = 6.86) in group A compared with group B (p < 0.001). In addition, there was a significant decrease in OSI (ES = 0.86), APSI (ES = 0.92), and MLSI (ES = 0.94) in group A compared with those of group B (p < 0.05). Furthermore, group A demonstrated a significant reduction in overall sway index (ES = 0.87), AP sway index (ES = 0.80), and ML sway index (ES = 0.81) compared with group B (p < 0.05). (Tables 2-4).

Table 2. Mean ICIQ-UI SF and Bladder base elevation pre and post treatment of group A and B:

	Group A	Group B			
	Mean ± SD	**Mean ± SD**	**MD (95% CI)**	**p value**	**ES**
ICIQ-UI SF					
Pre treatment	13.27 ± 2.78	13.46 ± 2.53	-0.19 (-2.19: 1.79)	0.84	
Post treatment	6.73 ± 3.01	13.07 ± 2.49	-6.34 (-8.40: -4.27)	0.001	2.30
MD (95% CI)	6.54 (5.86: 7.21)	0.39 (-0.27: 1.07)			
	p = 0.001	**p = 0.23**			
Bladder base elevation (cm)					
Pre treatment	0.17 ± 0.04	0.16 ± 0.05	0.01 (-0.02: 0.04)	0.68	
Post treatment	0.52 ± 0.06	0.17 ± 0.04	0.35 (0.30 : 0.39)	0.001	6.86
MD (95% CI)	-0.35 (-0.38: -0.32)	-0.01 (-0.05: 0.01)			
	p = 0.001	**p = 0.25**			

Mean; SD, Standard deviation; MD, Mean difference; CI, Confidence interval; p-value, probability value; ES, Cohen effect size

Table 3. Mean OSI, APSI and MLSI pre and post treatment of group A and B:

	Group A	Group B			
	Mean ± SD	**Mean ± SD**	**MD (95% CI)**	**p value**	**ES**
OSI					
Pre treatment	4.66 ± 1.28	4.38 ± 1.58	0.28 (-0.80: 1.35)	0.60	
Post treatment	2.60 ± 0.63	3.25 ± 0.87	-0.65 (-1.22: -0.08)	0.02	0.86
MD (95% CI)	2.06 (1.57: 2.54)	1.13 (0.65: 1.62)			
	p = 0.001	**p = 0.001**			
APSI					
Pre treatment	4.07 ± 1.48	4.03 ± 1.59	0.04 (-1.11: 1.19)	0.94	
Post treatment	2.15 ± 0.87	3.14 ± 1.24	-0.99 (-1.79: -0.20)	0.01	0.92
MD (95% CI)	1.92 (1.48: 2.37)	0.89 (0.45: 1.34)			
	p = 0.001	**p = 0.001**			
MLSI					
Pre treatment	1.64 ± 0.42	1.67 ± 0.49	-0.03 (-0.37: 0.32)	0.88	
Post treatment	1.08 ± 0.33	1.42 ± 0.39	-0.33 (-0.61: -0.06)	0.01	0.94
MD (95% CI)	-0.03 (0.42: 0.69)	-0.33 (0.12: 0.38)			
	p = 0.001	**p = 0.001**			

Mean; SD, Standard deviation; MD, Mean difference; CI, Confidence interval; p-value, probability value; ES, Cohen effect size

Table 4. Mean overall sway index, AP sway index and ML sway index pre and post treatment of group A and B:

	Group A	Group B			
	Mean ± SD	Mean ± SD	MD (95% CI)	p value	ES
Overall sway index					
Pre treatment	5.63 ± 1.10	5.24 ± 0.96	0.39 (-0.38: 1.16)	0.31	
Post treatment	3.35 ± 1.01	4.37 ± 1.32	-1.02 (-1.89: -0.13)	0.02	0.87
MD (95% CI)	2.28 (1.85: 2.70)	0.87 (0.45: 1.30)			
	p = 0.001	**p = 0.001**			
AP sway index					
Pre treatment	4.68 ± 1.11	4.64 ± 1.08	0.04 (-0.78: 0.86)	0.92	
Post treatment	2.88 ± 1.11	3.85 ± 1.30	-0.97 (-1.87: -0.06)	0.03	0.80
MD (95% CI)	1.80 (1.36: 2.24)	0.79 (0.36: 1.24)			
	p = 0.001	**p = 0.001**			
ML sway index					
Pre treatment	2.96 ± 0.85	2.85 ± 0.87	0.11 (-0.53: 0.75)	0.73	
Post treatment	1.95 ± 0.68	2.52 ± 0.73	-0.57 (-1.09: -0.04)	0.03	0.81
MD (95% CI)	1.01 (0.74: 1.28)	0.33 (0.06: 0.60)			
	p = 0.001	**p = 0.02**			

Mean; SD, Standard deviation; MD, Mean difference; CI, Confidence interval; p-value, probability value; ES, Cohen effect size

Discussion:

The aim of the present study was to examine the effect of PFMT on dynamic postural stability in postmenopausal females with SUI. Both groups proved that anthropometric and subject characteristic data are homogeneous, confirming the initial similarity and making it possible to analyze reliably findings generated between the groups.

The findings of the current study showed a significant decrease in ICIQ-UI in group A ($p < 0.001$) while there was no significant change in group B, which means that the PFMT improved urine leakage symptoms significantly compared to traditional physical and balance training alone. These results are supported by a RCT about the effect of PFMT versus hypopressive abdominal gymnastics (HAG) on SUI in climacteric women, also, Jahromi et al., examined the PFMT effect on UI and self-esteem of elderly females with SUI, both studies proved that there was a significant decrease in ICIQ-SF score in the PFMT group [26], [27].

The current result showed that there was a significant increase in bladder base elevation in group A ($p < 0.001$) while there was no significant change in group B. This result is proving that PFMT significantly enhanced PFM performance and strength compared to traditional physical and balance training alone. The intensive PFM strength training improving stiffness and hypertrophy of PFM and its connective tissue resulting in building up the pelvic structural support by elevating the levator-plate to a higher location within the pelvis permanently. Changes in the position of the urethrovesical junction during maximal voluntary PFM contraction were observed by ultrasound: such bladder neck elevation [28].

The current results agree with previous studies investigated the effect of PFMT on bladder neck mobility, and the effect of PFMT on PFM strength using ultrasonography in patients with UI respectively and concluded that PFM strengthening can highly improve PFM ability to elevate the bladder neck voluntarily [29], [30]. Furthermore, the current findings were confirmed by **Kuo,** who presented the video-urodynamic results in patients with SUI after PFMT and proved that the strengthened PFM reduces the degree of bladder neck descent during stress and increases the bladder base elevation during voluntary PF contractions [31].

We could not find a well-powered RCT in solely postmenopausal or elderly women that concluded definitively that PFMT does not increase bladder-base elevation. Most studies in older postmenopausal samples reported symptom strength benefit from PFMT, imaging (bladder-base elevation) is either not measured or measured with mixed results. There was one peer-reviewed study that reported no significant increase in bladder base elevation after PFMT but in a different population [32].

According to the authors knowledge, a very few studies have examined the effects of PFMT on dynamic postural stability in females with SUI. The current result showed that there was significant decrease in all stability and sway indices in both groups, however, there was significant decrease in all indices in group A compared with group B, which means that PFMT had a significant role in improving postural stability and balance. Literatures explained the relationship between PFM and balance, in one study on 22 middle-aged women investigated if PFM strength is associated with postural stability and concluded that PFM strength had a strong association with mediolateral displacement of COP in eyes-open semi-tandem and Anteroposterior COP median frequency in eyes-closed semi-tandem. These results means that there is some relationship between PFM strength and postural stability and thus, PFMT can enhance postural stability in middle-aged women [9].

These results were supported by a study compared between PFMT and spinal stabilization exercises in women with SUI and found that PFMT improved static balance in eyes open situation in women with SUI [11].

Furthermore, another study supported the current results by proving that women with SUI have impaired balance performance compared to continent women, this means that treatment of SUI by PFMT can also enhance balance performance [7].

Current results were opposed by **Leme et al.,** who carried out a single arm trial study investigated the effect of PFMT and postural balance in elderly women and concluded that the training protocol enhanced PFM strength and endurance, but did not positively affect balance. These results might be attributed to the increased age of the sample (over 60), sample with non-specific type of PFD and small intervention duration (5 weeks) [25].

Inconsistency between the current findings and other study findings, that may be resulted from the difference in the investigated population; Mihalova et al**.,** investigated the PFMT effect on fall risk in older females with urgency UI not SUI and in a relatively older population (mean age of 75± 4.3 years). No significant differences were found after treatment in timed up and go test (TUG) balance scores or the scores of the test with dual tasks (TUGDT) that considered a subjective method [10].

Strengthenings and limitations:

Several strengthening points of the present study includes, PFM performance assessed through ultrasound that considered an objective approach, also, dynamic postural stability was assessed by an objective method. Moreover, intervention program was performed by an experienced pelvic floor specialist. However, there are some limitations in this study. First, personal and individual differences between participants may affect evaluation stage. Secondly, the relatively small number of participants, finally, participants with higher BMI should be considered in future studies.

Conclusion:

It can be concluded that PFMT combined with physical & balance training, improved balance performance, PFM performance and decreased urinary symptoms in postmenopausal females with SUI. PFMT combined with physical & balance training may be an alternative method that should be considered in designing training programs for postmenopausal women regarding preventive strategies to decrease the prevalence of fall and injury.

Acknowledgments:

The authors would like to thank all females participated in the study.

Conflict of interest:

The authors have no conflict of interest.

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