



A Comparison of Pelvic Floor Muscle Exercises and Spinal Stabilization Exercises in Women with Stress Urinary Incontinence

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Abstract

Introduction and Hypothesis The objective was to compare the effects of pelvic floor muscle exercise (PFME) and spinal stabilization exercise (SSE) on urinary symptoms, pelvic floor muscle strength (PFMS), quality of life (QoL), core stability, balance, spinal posture, and perception of subjective improvement (PSI) in women with stress urinary incontinence (SUI).

Methods Patients were randomly divided into PFME ($n=25$) and SSE ($n=25$) groups. The exercises of both groups was applied 3 days a week for 8 weeks. Urinary symptoms, PFMS, QoL, core stability, balance, spinal posture, and PSI were assessed using the International Consultation on Incontinence Questionnaire-Short Form (ICIQ-SF) and pad test, the Modified Oxford Scale (MOS), the King's Health Questionnaire (KHQ), the Sahrman test, the Biodex Balance System, a Spinal Mouse device, and a Likert-type scale respectively.

Results The ICIQ-SF, pad test, KHQ, and static balance scores of both groups decreased, whereas the MOS and Sahrman scores increased ($p < 0.05$). All balance scores and sacral angles decreased in the SSE group ($p < 0.05$). The KHQ-Physical and KHQ-Emotional scores decreased more in the PFME group than in the SSE group, whereas core stability increased more and sacral angle decreased more in the SSE group than in the PFME group ($p < 0.05$). The PSI were similar ($p > 0.05$).

Conclusion Both PFME and SSE were effective in improving urinary symptoms, PFMS, QoL, and PSI in women with SUI. SSE was superior to PFME in improving core stability, balance, and sacral position. SSE may be an alternative method in the treatment of SUI.

Keywords Stress urinary incontinence · Spine stabilization · Pelvic floor muscle exercise · Spine posture · Quality of life

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Introduction

Stress urinary incontinence (SUI) is a complaint of involuntary urinary leakage due to situations where intra-abdominal pressure increases, such as sneezing or coughing [1]. Although its prevalence is reported to be 20–30% for young adults, this rate rises to 30–40% in middle-aged individuals [2]. This complaint negatively affects quality of life (QoL) and increases treatment costs [1].

Stress urinary incontinence occurs with the decrease in intrinsic urethral closure mechanism and external support mechanism such as pelvic floor muscle strength (PFMS) [1]. Pelvic floor muscles (PFMs) work synergistically with abdominal and back muscles; thus, these muscles support the spine and maintain core stability, the ability to control the position and movement of the trunk, and ensure the production and transfer of forces [3]. Impairment of the PFMs may cause a lack of core stability, lumbopelvic pain, and loss of balance in addition to SUI [4]. In the

literature, it was also reported that patients with SUI had more impaired balance and various postural problems than healthy individuals [5–7].

Pelvic floor muscle exercise (PFME) is an effective treatment method that reduces the severity of SUI and improves the QoL [1, 8]. However, no study has been found examining the effects of PFME on core stability, balance, and spinal posture in patients with SUI. Spinal stabilization exercise (SSE) also enables the development and maintenance of proper posture by activating deep trunk muscles and increasing kinesthetic awareness [9]. In recent years, SSE, in addition to PFME, has been used in the management of SUI [10–12]. Thus, there is a need to examine in detail the effects of SSE on SUI symptoms and on core stability, balance problems, and spinal posture that may accompany SUI.

Therefore, the current study was aimed at comparing the effects of PFME with those of SSE on urinary symptoms, PFMS, QoL, core stability, balance, spinal posture, and perception of subjective improvement (PSI) in women with SUI.

Materials and Methods

Study Design

This study, approved by the ethics committee of The University of Ankara Yildirim Beyazit (Approval date-no: 09.12.2021–33), was planned as a randomized clinical trial. It was registered at www.clinicaltrials.gov (NCT05193435) and performed at a physiotherapy and rehabilitation center between 10 January 2022 and 25 October 2022. Written informed consent was obtained from all participating individuals.

Patients and Randomization

Fifty-four volunteer women aged 18–65, diagnosed with SUI by a urology specialist, were included in the study (Fig. 1). The SUI diagnosis was made by using an extended clinical history, patient questionnaire (ICIQ-SF), and performing a physical examination that included a cough test and a urethral mobility and pelvic floor muscle contraction strength assessment. Exclusion criteria were urgency type urinary incontinence, advanced pelvic organ prolapse (grade ≥ 2), urinary infection, pregnancy,

history of malignancy, abdominal, spinal, and/or pelvic surgery in the last year, spinal deformity, neurological and/or rheumatological disease, and vestibular system disorders. Patients were randomly divided to either the PFME group or the SSE group. The computer-based block randomization procedure was used.

Intervention

Both SSE and PFME programs were implemented under the supervision of a physiotherapist, 3 days a week, every other day, for 8 weeks. The programs, planned based on studies in the literature [13, 14], were performed as 5–10 min of warm-up exercises, 20–30 min of exercise programs, and 5–10 min of cool-down exercises. The warm-up and cool-down period included stretching and mobility exercises for the abdominal, lumbo-pelvic, and hip regions.

Sessions lasted approximately 30–50 min. Although this period was shorter in the first weeks because there is a learning process and contraction times are short, it lengthens in the following weeks as the number and duration of exercises increase. Patients were taught how to contract and relax the PFMs using digital vaginal palpation applied by a physiotherapist and an EMG-biofeedback device (a device specially developed for the pelvic floor that graphs contractions and relaxations on a computer screen) with a probe inserted into the vagina. This protocol was applied to patients in both groups.

Pelvic Floor Muscle Exercise Programs

For the strength exercise, the patient was asked to contract and release for 1–2 s with strong (maximum) contractions and given 8–12 repetitions. For the endurance exercise, the patients were asked to contract their PFMs at a submaximal level and hold them for a certain period of time. The contraction duration was determined according to the patient's ability. It progressed to a maximum holding of 10 s. These exercises were also performed with 8–12 repetitions. In the speed exercises, the patients were asked to quickly contract and relax their PFMs with 3–5 repetitions. Rest periods of 5–6 s were created between contractions.

Exercises ranged from easy to difficult. They were performed in supine, prone, quadruped, sitting, kneeling, one-kneed, standing, and squat positions. Progress was achieved by increasing the number of exercise repetitions and moving on to the next difficult position. The exercises

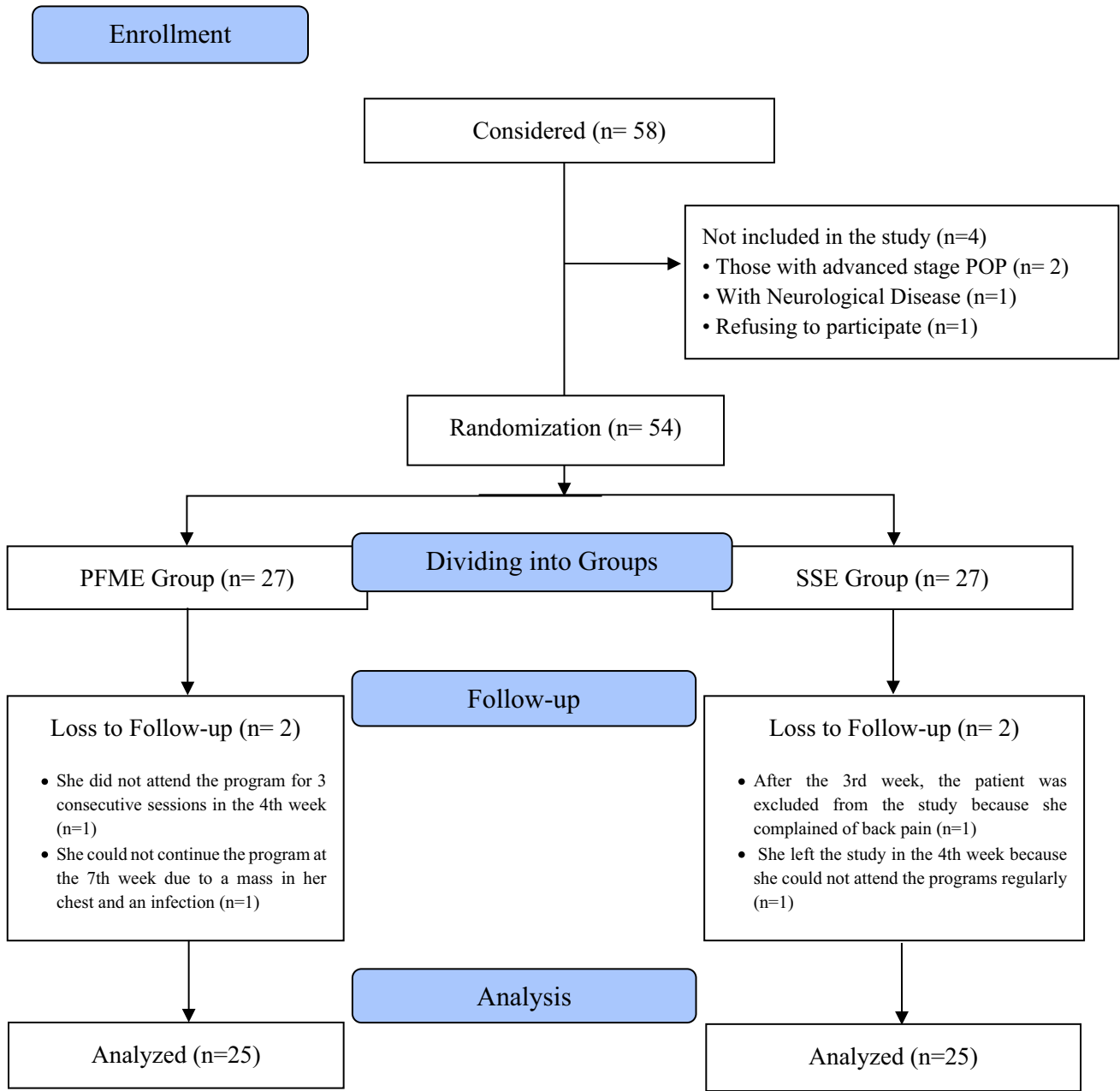


Fig. 1 Flow diagram of the study

were done only with the help of a physiotherapist; no home exercises were given.

Exercise Timeline

| | 1st and 2nd weeks | 3rd and 4th weeks | 5th and 6th weeks | 7th and 8th weeks |
|---------------------------|---|---|---|---|
| Exercise position | Supine Prone | Quadruped Sitting | Kneeling One-kneed | Standing Squat |
| The number of repetitions | 2 sets of strength exercise 2 sets of endurance exercise 2 sets of speed exercise | 3 sets of strength exercise 3 sets of endurance exercise 3 sets of speed exercise | 4 sets of strength exercise 4 sets of endurance exercise 4 sets of speed exercise | 5 sets of strength exercise 5 sets of endurance exercise 5 sets of speed exercise |

Spinal Stabilization Exercise Programs

Patients in the SSE group were taught how to apply the abdominal bracing technique, including transversus abdominis (TrA) muscle contraction, using a pressurized biofeedback unit. The exercise program was applied according to the stages of motor learning and sensory-motor integration and included static, dynamic, and functional phases. The static phase started with the abdominal bracing exercises according to the neurodevelopment stages. The exercises were carried out by holding the contraction at each position. In the dynamic phase, active range of motion of upper and lower limbs were performed while maintaining a stable spine with abdominal bracing at these specific positions. These exercises were also performed while maintaining a stable spine with abdominal bracing with elastic resistive bands. In the functional phase, the exercises were performed with elastic resistance and exercise balls on unstable surfaces. Patients performed the static phase exercises for the first 2 weeks, then the dynamic phase exercises in the 3rd and 5th weeks, and finally the functional phase exercise in the 6th and 8th weeks (Fig. 2). This group was not given home exercises either.

Exercise Timeline

| | 1st and 2nd weeks | 3rd and 5th weeks | 6th and 8th weeks |
|---------------------------|---|--|--|
| Exercise phase | Static phase | Dynamic phase | Functional phase |
| The number of repetitions | 2 set for each position (the static phase included 6 positions) | 2 set for each position (the dynamic phase included an average of 25–30 positions. Each session was performed with 5–6 positions from easy to difficult) | 2 set for each position (the functional phase included an average of 20–25 positions. Each session was performed with 8–10 positions from easy to difficult) |

Assessments

Physical and demographic characteristics were recorded (Table 1). Parameters were evaluated before treatment and after treatment (8th week). After treatment, patients’ PSI was questioned.

Urinary symptoms were evaluated using the IICIQ-SF [15] and 1-h pad test [16]. PFMS was evaluated using the Modified Oxford Scale (MOS) [17]. QoL was evaluated using the first part of the King’s Health Questionnaire (KHQ), which includes nine sub-dimensions [18]. Core stability was evaluated by the Sahrman test using a pressure biofeedback unit [19]. Balance was assessed by the Biodex Balance System using SD static mode and dynamic mode, whereas eyes were in open (EO) and closed (EC) positions. Spinal posture was measured using a Spinal Mouse® device. Patients’ PSI was assessed using a four-item Likert-type scale (worse, same, better, cured).

Sample Size

As there was to our knowledge no similar study in the literature, a pilot study related to our study was conducted on 10 women. Effect size was calculated as 0.505 according to the pad test results of this pilot study. It was detected that at least 46 patients were needed at 90% power for a 0.505 effect size and $\alpha=0.05$ using the G-Power 3.9.1 program. It was estimated that a total of 58 patients were recruited with a 20% data loss.

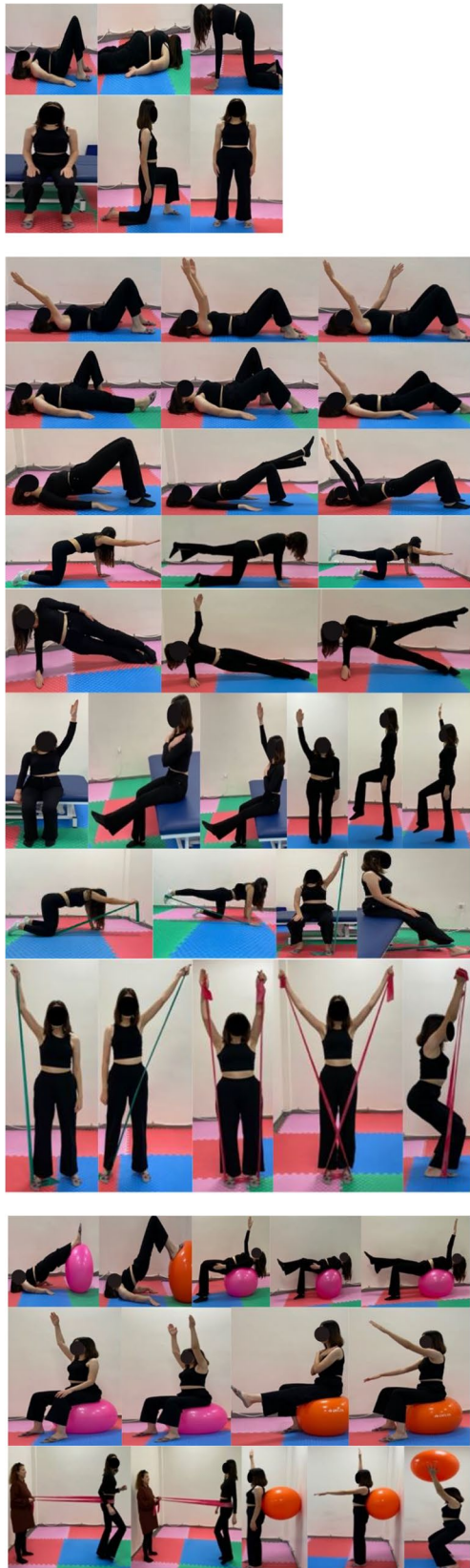


Fig. 2 Spinal stabilization exercise program. **a** Static phase exercise examples. **b** Dynamic phase exercise examples

Statistical Analyses

The suitability of normal distribution was tested using the Shapiro–Wilk test. Student’s *t* test was used to compare normally distributed variables in the two groups, and the Mann–Whitney *U* test was used to compare non-normally distributed variables in the two groups. Mixed analysis of variance (ANOVA) and least significant difference (LSD) tests were applied to test normally distributed variables in different groups and times. Repeated measurements of binary variables were compared using generalized estimating equations across different groups and times. Chi-squared test was used for categorical variables. The IBM SPSS Statistics for Windows, Version 22.0 program was used. The significance level was accepted as $p < 0.05$.

Results

Fifty-four patients were evaluated for eligibility, 4 patients were excluded from the study for various reasons (advanced pelvic organ prolapse ($n = 2$), neurological disease ($n = 1$), refusing to participate in the study ($n = 1$)). Twenty-five patients in the PFME group (age = 47.96 ± 9.52 years, BMI = 29.06 ± 4.9 kg/m²) and 25 patients in the SSE group (age = 47.36 ± 9.08 years, BMI = 28.08 ± 3.93 kg/m²) completed the study. Physical and demographic characteristics were similar between groups at baseline ($p > 0.05$). No adverse effects were reported during the study.

There was a difference between two time-dependent measurements (BT–AT) of the groups’ pad test ($p = 0.001$) and ICIQ-SF values ($p = 0.001$). Moreover, a difference was detected between the groups in terms of KHQ-General Health, KHQ-Physical Limitations, KHQ-Emotional and KHQ-Sleep/Energy scores ($p < 0.05$). A difference was observed between the two time-dependent measurements (BT–AT) of the groups for all sub-dimensions of the KHQ ($p < 0.05$). An interaction was detected between group and time in the KHQ-Physical Limitation and KHQ-Emotional scores ($p < 0.05$). The improvement in the PFME group was greater than that in the SSE group (Table 2).

No difference was found between the groups in terms of MOS values ($p = 0.05$). A difference was detected between the two time-dependent measurements (BT–AT) for the MOS value of the groups ($p = 0.001$). A difference was found between the groups in terms of Sahrman test scores ($p = 0.001$). A difference was detected between the two time-dependent measurements (BT–AT) in the Sahrman test scores of the groups ($p = 0.001$). There was an interaction between group and time for these scores ($p = 0.001$).

Table 1 Comparison of physical, demographic, and clinical characteristics of the groups

| | PFME group (<i>n</i> = 25) | SSE group (<i>n</i> = 25) | <i>p</i> |
|---|-----------------------------|----------------------------|----------|
| Age (years) ^a | 47.96 ± 9.52 | 47.36 ± 9.08 | 0.821* |
| BMI (kg/m ²) ^a | 29.06 ± 4.9 | 28.08 ± 3.93 | 0.436* |
| Marital status ^b | | | 0.636** |
| Married | 23 (92) | 22 (88) | |
| Single | 2 (8) | 3 (12) | |
| Smoking status ^b | | | 1.000** |
| Yes | 3 (12) | 3 (12) | |
| No | 22 (88) | 22 (88) | |
| Alcohol use ^b | | | 1.000** |
| Yes | 1 (4) | 1 (4) | |
| No | 24 (96) | 24 (96) | |
| Chronic constipation ^b | | | 0.758** |
| Yes | 8 (32) | 7 (28) | |
| No | 17 (68) | 18 (72) | |
| Educational status ^b | | | 0.975** |
| Primary school | 5 (20) | 4 (16) | |
| Secondary school | 6 (24) | 5 (20) | |
| High school | 6 (24) | 7 (28) | |
| License | 6 (24) | 6 (24) | |
| Graduate school | 2 (8) | 3 (12) | |
| Number of pregnancies ^c | 3 (0–5) | 3 (0–7) | 0.762*** |
| Number of births ^c | 3 (0–5) | 3 (0–3) | 0.558*** |
| Birth type ^b | | | 0.968** |
| Vaginal | 15 (60) | 15 (60) | |
| Cesarean section | 3 (12) | 4 (16) | |
| Both | 5 (20) | 4 (16) | |
| None | 2 (8) | 2 (8) | |
| Large baby (> 4,000 g) ^b | | | 0.572** |
| Yes | 6 (24) | 4 (17.4) | |
| No | 9 (76) | 19 (82.6) | |
| Episiotomy ^b | | | 0.555** |
| Yes | 12 (48) | 13 (56.5) | |
| No | 13 (52) | 10 (43.5) | |
| Menopause ^b | | | 0.114** |
| Yes | 18 (72) | 12 (50) | |
| No | 7 (28) | 12 (50) | |
| Menopause duration (years) ^a | 8.78 ± 4.81 | 6.92 ± 4.81 | 0.338* |
| Complaint duration (years) ^c | 4.5 (1–15) | 5 (1–16) | 0.641*** |

PFME pelvic floor muscle exercise, SSE spinal stabilization exercise, SD standard deviation, BMI body mass index

*Student's *t* test, **Chi-squared test, ***Mann–Whitney *U* test

^aMean (SD), ^b*n* (%), ^cMedian (minimum to maximum)

The increase in Sahrman test scores in the SSE group was greater than that in the PFME group.

A difference was detected between the two time-dependent measurements (BT–AT) in the static-EO balance scores of the groups ($p < 0.05$). In the SSE group, there was a difference between the two time-dependent measurements (BT–AT) of static-EC, dynamic-EO, and dynamic-EC

balance scores ($p < 0.05$), whereas in the PFME group there was no difference ($p > 0.05$). Furthermore, a difference was observed for only sacral angle value in the SSE group ($p < 0.05$). The decrease in the sacral angle in the SSE group was greater than that in the PFME group ($p < 0.05$; Table 3).

Within the PFME group, 8% ($n = 2$) of the participants experienced some improvements in symptoms, whereas 92%

Table 2 Comparison of the International Consultation on Incontinence Questionnaire-Short Form (ICIQ-SF), pad test, and King's Health Questionnaire (KHQ) scores according to groups and time

| | PFME group (<i>n</i> = 25), mean ± SD | SSE group (<i>n</i> = 25), mean ± SD | BG, <i>p</i> value | GTI, <i>p</i> value |
|----------------------------|---|---|--------------------|---------------------|
| ICIQ-SF total score | | | 0.193 | 0.290 |
| BT | 12.36 ± 3.87 | 11.72 ± 4.34 | | |
| AT | 2.4 ± 3.29 | 0.76 ± 1.85 | | |
| WG, <i>p</i> value | 0.001* | 0.001* | | |
| 1-h pad test | | | 0.417 | 0.479 |
| BT | 13.28 ± 13.28 | 10.8 ± 8.43 | | |
| AT | 1.12 ± 4.04 | 0.4 ± 1.8 | | |
| WG, <i>p</i> value | 0.001* | 0.001* | | |
| KHQ | | | | |
| KHQ-General Health | | | 0.007* | 0.635 |
| BT | 38 ± 14.65 | 31 ± 14.93 | | |
| AT | 31 ± 10.9 | 22 ± 8.29 | | |
| WG <i>p</i> value | 0.035* | 0.007* | | |
| KHQ-Incontinence Impact | | | 0.699 | 0.131 |
| BT | 65.33 ± 29.63 | 69.33 ± 21.34 | | |
| AT | 14.67 ± 23.73 | 6.67 ± 13.61 | | |
| WG, <i>p</i> value | 0.001* | 0.001* | | |
| KHQ-Role Limitations | | | 0.307 | 0.349 |
| BT | 48 ± 30.93 | 39.33 ± 27.59 | | |
| AT | 4 ± 11.06 | 2.67 ± 9.23 | | |
| WG, <i>p</i> value | 0.001* | 0.001* | | |
| KHQ-Physical Limitations | | | 0.014* | 0.030* |
| BT | 64.67 ± 25.15 | 44 ± 32.94 | | |
| AT | 6 ± 8.16 | 2.67 ± 9.23 | | |
| WG, <i>p</i> value | 0.001* | 0.001* | | |
| KHQ-Social Limitations | | | 0.338 | 0.628 |
| BT | 32 ± 25.92 | 26.22 ± 27.76 | | |
| AT | 3.11 ± 7.54 | 0.89 ± 4.44 | | |
| WG, <i>p</i> value | 0.001* | 0.001* | | |
| KHQ-Personal Relationships | | | 0.852 | 0.363 |
| BT | 27.33 ± 32.23 | 30 ± 31.91 | | |
| AT | 5.33 ± 12.47 | 0.67 ± 3.33 | | |
| WG, <i>p</i> value | 0.002* | 0.001* | | |
| KHQ-Emotional State | | | 0.031* | 0.024* |
| BT | 50.22 ± 28.53 | 30.67 ± 30.48 | | |
| AT | 2.67 ± 9.23 | 1.33 ± 6.67 | | |
| WG, <i>p</i> value | 0.001* | 0.001* | | |
| KHQ-Sleep/Energy | | | 0.043* | 0.060 |
| BT | 35.33 ± 33.1 | 17.33 ± 30.23 | | |
| AT | 0.67 ± 3.33 | 0 ± 0 | | |
| WG, <i>p</i> value | 0.001* | 0.007* | | |
| KHQ-Severity Measures | | | 0.105 | 0.587 |
| BT | 50.93 ± 20.17 | 42.93 ± 23.42 | | |
| AT | 8.53 ± 13.27 | 3.73 ± 6.69 | | |
| WG, <i>p</i> value | 0.001* | 0.001* | | |

BT before treatment, *AT* after treatment, *WG* within-group comparison, *PFME* pelvic floor muscle exercise, *SSE* spinal stabilization exercise, *BG* between-group comparison, *GTI* group*time interaction, *SD* standard deviation

**p* < 0.05 significance level

Table 3 Comparison of static-dynamic balance and spinal posture according to groups and time

| | PFME group (<i>n</i> =25), mean ± SD | SSE group, (<i>n</i> =25; mean ± SD | BG, <i>p</i> value | GTI, <i>p</i> value |
|-------------------------------------|---|--|--------------------|---------------------|
| Balance | | | | |
| Static balance general eyes open | | | | |
| BT | 1.44 ± 0.87 | 1.49 ± 1.14 | 0.586 | 0.057 |
| AT | 1.2 ± 0.66 | 0.92 ± 0.58 | | |
| WG, <i>p</i> value | 0.007* | 0.001* | | |
| Static balance general eyes closed | | | | |
| BT | 1.65 ± 0.8 | 1.77 ± 0.77 | 0.559 | 0.894 |
| AT | 1.53 ± 0.67 | 1.64 ± 0.65 | | |
| WG <i>p</i> value | 0.110 | 0.018* | | |
| Dynamic balance general eyes open | | | | |
| BT | 5.28 ± 1.78 | 5.25 ± 1.93 | 0.854 | 0.434 |
| AT | 5.02 ± 1.8 | 4.86 ± 1.9 | | |
| WG, <i>p</i> value | 0.103 | 0.001* | | |
| Dynamic balance general eyes closed | | | | |
| BT | 7.02 ± 1.6 | 7.09 ± 2.16 | 0.985 | 0.234 |
| AT | 6.93 ± 1.73 | 6.84 ± 1.89 | | |
| WG, <i>p</i> value | 0.432 | 0.004* | | |
| Spine posture | | | | |
| Thoracic angle | | | | |
| BT | 53.4 ± 8.55 | 53.68 ± 10.41 | 0.673 | 0.140 |
| AT | 52.64 ± 8.3 | 50.08 ± 12.44 | | |
| WG, <i>p</i> value | 0.145 | 0.060 | | |
| Lumbar angle | | | | |
| BT | −35 ± 8.52 | −35.24 ± 11.29 | 0.811 | 0.443 |
| AT | −33.76 ± 6.8 | −32.36 ± 10.01 | | |
| WG, <i>p</i> value | | 0.071 | 0.166 | |
| Sacral angle | | | | |
| BT | 21.04 ± 4.69 | 21.48 ± 7.8 | 0.676 | 0.025* |
| AT | 20.6 ± 4.45 | 18.88 ± 4.92 | | |
| WG, <i>p</i> value | 0.229 | 0.006* | | |

BT before treatment, AT after treatment, WG within-group comparison, BG between-group comparison, GTI group*time interaction, SD standard deviation

**p* < 0.05 significance level

(*n* = 23) reported complete resolution of symptoms. Within the SSE group, 16% (*n* = 4) of the participants reported improvements in symptoms, whereas 84% (*n* = 21) experienced full symptom resolution.

Discussion

The present study found that both PFME and SSE were effective in decreasing urinary symptoms and increasing PFMS, QoL, and PSI in women with SUI. Moreover, PFME was superior to SSE in improving some parameters related to the QoL, whereas SSE was superior to PFME in improving core stability, balance, and sacral position.

The first recommended conservative treatment approach in SUI is PFME [1, 8]. Dumoulin et al. reported that the effect of PFME on SUI was eight times greater than that of other types of urinary incontinence [20]. In recent years, abdominal exercises in addition to PFME or only TrA muscle contraction, a part of SSE, in addition to PFME, have been recommended in the treatment of urinary incontinence. Sakipour and Mojtahedi investigated the effects of SSE on urinary incontinence in older women with urinary incontinence and found that there were significant improvements in urinary incontinence symptoms [21]. Nipa et al. found that in women with SUI and low back pain, the recovery rate in the PFME + SSE group was higher than in the PFME alone group [22]. It was reported that reductions in low back pain

and urinary incontinence symptoms were observed with the SSE focusing on the pelvic floor [10, 12]. Our study reported that both PFME and SSE reduced the severity of urinary symptoms. These results of the PFME group may be attributed to improving external support on the urethral sphincter mechanism with the increase in PFMS. The results of the SSE group may be attributed to the strengthening of the stability cylinder with the increase in core stability. However, it was observed that there were similar results between the groups in terms of improvement in urinary incontinence severity.

It is important to increase PFMS in the management of SUI. Kharaji et al. reported that PFME shows strong evidence for improvements in PFMS [23]. Furthermore, in patients with urinary incontinence, it was reported that SSE given in addition to PFME increased PFMS [24, 25], and in a study in which only SSE was applied, improvements in PFMS were reported [23]. In our study, an increase in PFMS was observed in both the PFME and SSE groups; however, there was no difference between the groups. PFME and SSE can be considered as alternative applications to improve PFMS.

Quality of life is an important parameter in the success of urinary incontinence management. Radzimińska et al. found that PFME improved the QoL, which is an important determinant of the physical, psychological, and social functions of women with urinary incontinence [25]. Far et al. investigated the effects of dynamic neuromuscular stabilization exercises in elderly women with urinary incontinence and found that these exercises improved urinary incontinence and QoL [26]. De Souza Abreu et al. found that the QoL in women with SUI increased more in the SSE + PFME group than in the PFME group [11]. In our study, both PFME and SSE improved all QoL parameters in women with SUI. Moreover, the PFME group showed more improvement in some parameters (physical limitations, emotional state) than the SSE group. Both exercise approaches can be recommended to patients with SUI to improve their QoL.

Coactivation of the PFM and TrA muscles in controlling the increase in intra-abdominal pressure contributes to sufficient intra-urethral pressure to maintain continence [27]. In a review by Bø et al., they stated that PFM contraction occurs during TrA muscle contraction in healthy women, but this coactivation is weakened in patients with urinary incontinence [28]. It was also reported that the lateral abdominal muscle (TrA and internal oblique) contraction function was reduced in patients with SUI [29]. According to this information, PFME and/or SSE can be used in the treatment of SUI. To our knowledge, there was no study examining the effects of PFME on core stability in patients with SUI. In our study, it was found that PFME

had positive effects on core stability. We think that PFME should not be forgotten in patients who need to support core stability. Moreover, Ghaderi et al. found that SSE focusing on the pelvic floor increased TrA muscle strength in women with urinary incontinence and low back pain [10]. It was reported that SSE focusing on the pelvic floor increased TrA muscle strength in postpartum women with SUI [12]. In our study it was seen that SSE improved core stability more than PFME in patients with SUI. It may be beneficial to recommend SSE to these patients with inadequate core stability.

There are many reasons for loss of balance in patients with urinary incontinence, such as trunk muscle weakness, fear of urinary incontinence, and impaired walking speed and mobility [4]. To the knowledge of the authors, there are no studies examining the effects of PFME and SSE on balance in patients with SUI. Our study was found that PFME improved only static balance (EO) in women with SUI, whereas SSE improved both static and dynamic balance. These results may be attributed to the decrease in the severity of SUI and the improvement in core stability. In clinics, SSE may be more useful with regard to the balance problems accompanying SUI.

Changes in pelvic floor or trunk muscle activation in patients with SUI could cause deteriorations in pelvic and trunk control [30]. Celenay and Kaya reported that thoracic, lumbar, and sacral angles were greater in individuals with SUI than in those without SUI [6]. Our study observed that PFME was not associated with a significant change in spinal posture. However, SSE was associated with a decrease in the sacral angle. These results may be attributed to the greater effects of SSE on core stability and postural control. Additionally, reducing the sacral angle with SSE may also contribute to reducing abnormal stress on the pelvic floor and incontinence complaints. SSE may be an alternative approach for patients with SUI who have postural dysfunction.

One limitation of our study was the lack of blinding. This was due to insufficient personnel and may lead to bias in the studies. In addition, the lack of a control group and the small number of participants were other limitations. These issues should be taken into account in future studies.

The strength of our study is that it compared PFME and SSE and that all exercises were performed by an experienced pelvic floor provider who was trained in pelvic floor health.

In conclusion, both PFME and SSE improved urinary symptoms, PFMS, QoL, and PSI in women with SUI. Furthermore, PFME was superior to SSE in improving QoL, whereas SSE was superior to PFME in improving core stability, balance, and sacral position. SSE may be an alternative method in the management of SUI.

Authors' Contributions M.S. Bagbanci: diagnosis; E.B. Demirdogen: project development, data collection, manuscript writing; S.T. Celenay: project development, data management, manuscript writing; T. Ulcay: project development, manuscript writing.

Declarations

Ethics Approval The ethical suitability of the study was approved by the Ethics Committee of Ankara Yıldırım Beyazıt University with the decision number 33 dated 9 December 2021.

Conflicts of Interest None.

References

- Haylen BT, de Ridder D, Freeman RM, Swift SE, Berghmans B, Lee J, et al. An International Urogynecological Association (IUGA)/International Continence Society (ICS) joint report on the terminology for female pelvic floor dysfunction. *Neurourol Urodyn*. 2010;29(1):4–20. <https://doi.org/10.1002/nau.20798>.
- Hunnskaar S, Lose G, Sykes D, Voss S. The prevalence of urinary incontinence in women in four European countries. *BJU Int*. 2004;93(3):324–30. <https://doi.org/10.1111/j.1464-410X.2003.04609.x>.
- Richardson C, Jull G, Hides J, Hodges P. Therapeutic exercise for spinal segmental stabilization in low back pain. London: Churchill Livingstone; 1999.
- Smith MD, Coppiters MW, Hodges PW. Is balance different in women with and without stress urinary incontinence? *Neurourol Urodyn*. 2008;27(1):71–8. <https://doi.org/10.1002/nau.20476>.
- Ahmadi M, Manshadi FD, Rahimi A, Baghban AA. Static and dynamic balance in women with and without stress urinary incontinence. *Sci J Rehabil Med*. 2020;9(3):197–204. <https://doi.org/10.22037/jrm.2020.112490.2201>.
- Çelenay ŞT, Kaya DÖ. Relationship of spinal curvature, mobility, and low back pain in women with and without urinary incontinence. *Turk J Med Sci*. 2017;47(4):1257–62. <https://doi.org/10.3906/sag-1609-67>.
- Iguchi S, Inoue-Hirakawa T, Nojima I, Noguchi T, Sugiura H. Relationships between stress urinary incontinence and trunk muscle mass or spinal alignment in older women. *Low Urin Tract Symptoms*. 2022;14(1):10–6. <https://doi.org/10.1111/luts.12403>.
- Cacciari LP, Dumoulin C, Hay-Smith EJ. Pelvic floor muscle training versus no treatment, or inactive control treatments, for urinary incontinence in women: a Cochrane systematic review abridged republication. *Braz J Phys Ther*. 2019;23(2):93–107. <https://doi.org/10.1016/j.bjpt.2019.01.002>.
- Kisner C, Colby LA, Borstad J. Therapeutic exercise: foundations and techniques. Philadelphia, PA: Davis; 2017.
- Ghaderi F, Mohammadi K, Sasan RA, Kheslat SN, Oskouei AE. Effects of stabilization exercises focusing on pelvic floor muscles on low back pain and urinary incontinence in women. *Urology*. 2016;93:50–4. <https://doi.org/10.1016/j.urology.2016.03.034>.
- De Souza Abreu N, de Castro Villas Boas B, Bastos Netto JM, Figueiredo AA. Dynamic lumbopelvic stabilization for treatment of stress urinary incontinence in women: Controlled and randomized clinical trial. *Neurourol Urodyn*. 2017;36(8):2160–8. <https://doi.org/10.1002/nau.23261>.
- Khorasani F, Ghaderi F, Bastani P, Sarbakhsh P, Berghmans B. The effects of home-based stabilization exercises focusing on the pelvic floor on postnatal stress urinary incontinence and low back pain: a randomized controlled trial. *Int Urogynecol J*. 2020;31:2301–7. <https://doi.org/10.1007/s00192-020-04284-7>.
- Bø K. Physiotherapy management of urinary incontinence in females. *J Physiother*. 2020;66(3):147–54. <https://doi.org/10.1016/j.jphys.2020.06.011>.
- Kaya DO, Ergun N, Hayran M. Effects of different segmental spinal stabilization exercise protocols on postural stability in asymptomatic subjects: randomized controlled trial. *J Back Musculoskelet Rehabil*. 2012;25(2):109–16. <https://doi.org/10.3233/BMR-2012-0318>.
- Çetinel B, Özkan B, Can G. ICIQ-SF Türkçe versiyonu validasyon (geçerlilik) çalışması. *Türk Ürol Derg*. 2004;30(3):332–8.
- Abdel-Fattah M, Barrington J, Youssef M. The standard 1-hour pad test: does it have any value in clinical practice? *Eur Urol*. 2004;46(3):377–80. <https://doi.org/10.1016/j.eururo.2004.04.018>.
- Bo K, Sherburn M. Perspectives—evaluation of female pelvic-floor muscle function and strength. *Phys Ther*. 2005;85(3):269–82. <https://doi.org/10.17784/mtprehabjournal.2019.17.707>.
- Kaya S, Akbayrak T, Toprak Çelenay Ş, Dolgun A, Ekici G, Beksaç S. Reliability and validity of the Turkish King's Health Questionnaire in women with urinary incontinence. *Int Urogynecol J*. 2015;26:1853–9. <https://doi.org/10.1007/s00192-015-2786-6>.
- Stanton R, Reaburn PR, Humphries B. The effect of short-term Swiss ball training on core stability and running economy. *J Strength Cond Res*. 2004;18(3):522–8. <https://doi.org/10.1519/00124278-200408000-00023>.
- Dumoulin C, Cacciari LP, Hay-Smith EJC. Pelvic floor muscle training versus no treatment, or inactive control treatments, for urinary incontinence in women. *Cochrane Database Syst Rev*. 2018;10(10):CD005654. <https://doi.org/10.1002/14651858.CD005654.pub4>.
- Sakipour F, Mojtahedi H. Effect of spinal stabilization exercises to reduce urinary incontinence in the elderly. *Res Sports Med Technol*. 2017;15(13):61–9.
- Nipa SI, Sriboonreung T, Paungmali A, Phongnarisorn C. The effects of pelvic floor muscle exercise combined with core stability exercise on women with stress urinary incontinence following the treatment of nonspecific chronic low back pain. *Adv Urol*. 2022;2022:2051374. <https://doi.org/10.1155/2022/2051374>.
- Kharaji G, ShahAli S, Ebrahimi-Takamjani I, Sarrafzadeh J, Sanaei F, Shanbehzadeh S. Supervised versus unsupervised pelvic floor muscle training in the treatment of women with urinary incontinence—a systematic review and meta-analysis. *Int Urogynecol J*. 2023;34(7):1339–49. <https://doi.org/10.1007/s00192-023-05489-2>.
- Ghaderi O, Sadati SKM, Daneshjoo A. Effect of core stability exercises and pelvic muscle exerciser apparatus on pelvic floor muscle strength, quality of life and sexual satisfaction in women with urinary incontinence and uterine prolapse. *J Clin Physiother Res*. 2021;6(3):e38. <https://doi.org/10.22037/jcpr.v6i3.33934>.
- Radziemińska A, Strączyńska A, Weber-Rajek M, Styczyńska H, Strojek K, Piekorz Z. The impact of pelvic floor muscle training on the quality of life of women with urinary incontinence: a systematic literature review. *Clin Interv Aging*. 2018;13:957–65. <https://doi.org/10.2147/CIA.S160057>.
- Farzin FM, Mohammad RN. The effect of dynamic neuromuscular stabilization exercises on urine control and quality of life in elderly women. *J Saf Promot Inj Prevention*. 2022;10(1):33–42. <https://doi.org/10.22037/iipm.v10i1.35878>.
- Neumann P, Gill V. Pelvic floor and abdominal muscle interaction: EMG activity and intra-abdominal pressure. *Int Urogynecol J*. 2002;13:125–32. <https://doi.org/10.1007/s001920200027>.
- Bø K, Mørkved S, Frawley H, Sherburn M. Evidence for benefit of transversus abdominis training alone or in combination with pelvic floor muscle training to treat female urinary incontinence: a systematic review. *Neurourol Urodyn*. 2009;28(5):368–73. <https://doi.org/10.1002/nau.20700>.

29. Celenay ST, Balaban M, Kaya DO. Lateral abdominal muscle thickness and contractile function in women with and without stress urinary incontinence. *Int Urogynecol J*. 2024;35(2):303–9. <https://doi.org/10.1007/s00192-023-05636-9>.
30. Bush HM, Pagorek S, Kuperstein J, Guo J, Ballert KN, Crofford LJ. The association of chronic back pain and stress urinary incontinence: a cross-sectional study. *J Womens Health Phys Therap*. 2013;37(1):11. <https://doi.org/10.1097/JWH.0b013e31828c1ab3>.

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