Effect of Pelvic-Floor Muscle Exercise Position on Continence and Quality-of-Life Outcomes in Women With Stress Urinary Incontinence

Background and Purpose. Pelvic-floor muscle (PFM) exercises are effective in reducing stress urinary incontinence (SUI), but few studies have investigated the effect of specific exercise variables on treatment outcomes. This study explored the effect of exercise position on treatment outcomes in women with SUI. Subjects and Methods. Forty-four women were randomly assigned to exercise in the supine position only or in both supine and upright positions. Bladder diary, pad test, urodynamic test, quality-of-life (Incontinence Impact Questionnaire [IIQ]), and PFM strength outcomes were obtained at baseline and after treatment. Results. Exercise position did not affect outcomes. After data from both groups were collapsed, statistically significant improvements with treatment were observed in bladder diary, IIQ, PFM strength, and urodynamic test results. Discussion and Conclusion. Exercise position did not differentially affect treatment outcomes. However, women in this study achieved a mean 67.9% reduction in the frequency of SUI episodes and improvements in other study outcomes. [Borello-France DF, Zyczynski HM, Downey PA, et al. Effect of pelvic-floor muscle exercise position on continence and quality-of-life outcomes in women with stress urinary incontinence. Phys Ther. 2006;86:974–986.]

Key Words: Exercise, Pelvic floor, Urinary stress incontinence.

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tress urinary incontinence (SUI) is the involun-
tary loss of urine that occurs with physical
exertion and a rise in abdominal pressure.1
Coughing, sneezing, straining, jumping, and
running are events commonly associated with SUI.
Mechanisms underlying the development of SUI include
pudendal nerve injury during vaginal delivery,2 incom-
plete pudendal nerve regeneration after delivery,3 and
loss of muscular, ligamentous, and fascial support of the
urethra and bladder.4 Symptoms of SUI occur when the
anatomic and functional integrity of the urethral sphinct-
ter complex cannot resist forces associated with
increases in intra-abdominal pressure. Because the leva-
tor ani muscles contribute to continence by providing
support to pelvic organs and by enhancing urethral
closure,5,6 pelvic-floor muscle (PFM) exercises have been
recommended in the initial conservative management of
SUI.7

Since the introduction of Kegel exercises in 1948,8 the
efficacy of PFM exercises in the treatment of SUI and
mixed urinary incontinence (symptoms of stress incon-
tinence and urge incontinence) has been supported by
the findings of several randomized controlled studies
and systematic reviews.9-14 Compared with 3% cure and
15% improved continence rates for controls, Burns et al9
reported that 16% of women receiving PFM exercise
training were cured and that 44% reported 50% to 99%
improvement in symptoms. In a study carried out by Bo
et al,10 56% of women who received PFM exercise
training perceived their condition as “unproblematic”
after treatment compared with only 3% of controls.
Henalla et al11 reported that 65% of women who
received PFM exercise training had at least a 50%
reduction in urine loss on a pad test compared with no
reduction in urine loss for the control group. Using
biofeedback-assisted PFM exercise training and self-
monitoring with bladder diaries, Goode et al12 found
that women with predominant SUI symptoms showed a
mean 68.6% reduction in the frequency of incontinence
episodes compared with a mean 52.5% reduction in
incontinence episodes for controls, who were given
comprehensive written instructions in the form of an
8-week self-help behavioral program. Differences in out-
come measures and rehabilitation methods, including
the use of biofeedback, the number of muscle contrac-
tions performed per day, and specific muscle contraction
variables (eg, contraction duration and emphasis on
endurance versus strength training), may account for
differences in reported success or improvement
rates.9-12 Thus, although PFM exercises have been
accepted as an effective intervention for SUI, many
questions regarding exercise guidelines are not yet
answered.

Evidence to guide PFM rehabilitation from both exercise
physiology and functional perspectives is needed. The
amount and timing of PFM force may be task depen-
dent. Pelvic-floor muscle exercises often are taught and
practiced with the participant in a relaxed, supine posi-
tion. Whether or not the benefits of training gained in
this context are adaptable to muscle strength (force-
generating capacity) and coordination demands associ-
ated with more functional contexts is unknown. How-
ever, the findings of a recent study aimed at identifying
differences in PFM strength measurements obtained in

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Dr Borello-France and Dr Downey provided concept/idea/research design. Dr Borello-France and Dr Zyczynski provided writing, project
management, fund procurement, and institutional liaisons. Dr Borello-France, Dr Downey, and Ms Rause provided data collection, and Dr
Borello-France provided data analysis. Dr Zyczynski provided subjects and facilities/equipment. Dr Zyczynski, Dr Downey, and Dr Wister provided
consultation (including review of manuscript before submission).

All study procedures were approved by the institutional review boards of Duquesne University, University of Pittsburgh, and Chatham College.

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supine and standing positions suggest that muscle demands may be influenced by position. Using a vaginal balloon catheter connected to a pressure transducer, Bo and Finckenhagen\textsuperscript{15} observed that the mean resting vaginal pressure was 8.6 cm of H\textsubscript{2}O higher when recorded with women standing than when recorded with women lying supine. No differences were observed in the subjects’ abilities to produce maximum squeeze pressure or maximum contraction duration when the 2 postures were compared. The higher resting pressure recorded during standing suggests that vaginal pressure may be influenced by gravity.\textsuperscript{15}

If muscle activity demands are influenced by body position, then a PFM exercise program performed in a gravity-eliminated position may be less effective than one performed in upright positions. The aim of the current investigation was to compare the efficacy of a PFM exercise progression that included practice in upright positions (supine, sitting, and standing) with the efficacy of one that included practice in the supine position only in reducing female SUI. We hypothesized that women who exercised in both the supine and upright positions would have better urinary, strength, and quality-of-life outcomes than would women who exercised in the supine position only.

**Method**

**Subject Recruitment and Screening**

Recruitment sources included local newspaper advertisements, the Magee-Womens Research Institute Web site, and physician referrals from the Department of Obstetrics, Gynecology, and Reproductive Science at the University of Pittsburgh at Magee-Womens Hospital. Potential subjects were screened by telephone (by CR or DBF) or in person (by CR) after signing the Magee-Womens Hospital Research Registry for Women and Infant’s Health) to determine eligibility for examination. To be eligible, women had to be 38 to 70 years of age, not pregnant, and ambulatory. They also had to describe symptoms of SUI occurring at least once a week, and they had to deny symptoms of urgency or urge urinary incontinence (UUI). To screen for UUI symptoms, women were asked whether they leaked urine when they coughed, sneezed, laughed, or exercised or with physical exertion, such as lifting something heavy or moving furniture. To screen for UUI symptoms, women were asked whether they believed they emptied their bladder too often, whether they frequently experienced a sudden desire to urinate that could not be stopped, whether urine leakage occurred with a sudden and strong desire to urinate that could not be stopped, or whether they experienced urine leakage on the way to the bathroom. Women were considered ineligible if they indicated prior treatments for SUI (collagen injection, medications affecting bladder tone, pessary, or surgery). In addition, they were considered ineligible if they had been taught how to contract their PFMs and had been prescribed a PFM exercise program by a physician, nurse, physical therapist, or other health care professional. Additional exclusion criteria included having a pacemaker, using an intrauterine device, or having a medical history of pelvic cancer, severe endometriosis, or neurologic or metabolic disorders likely to impair bladder or sphincter function. Eligible subjects were sent a baseline bladder diary and were scheduled for a clinical examination.

**Pretreatment Examination**

Subjects provided informed consent before initiation of the clinical examination. A nurse practitioner and a physical therapist examined all subjects. The clinical examination consisted of a medical history and bladder diary review, physical examination, and urodynamic evaluation.

The nurse practitioner performed all urodynamic evaluations. Urodynamic evaluations with external water pressure transducers were performed with an EKO Urodynamics System,\textsuperscript{*} a no. 7 French double-lumen urethral catheter,\textsuperscript{†} and a rectal balloon catheter\textsuperscript{‡} to measure intra-abdominal pressure. Postvoid residual urine was removed through the urodynamic catheter before bladder filling. Transducers were zeroed to each subject. Postvoid residual urine was documented by catheterization within 15 minutes of voiding. The bladder was retrograde filled with room temperature sterile water at a continuous rate of 50 mL/min. Bladder filling stopped when the subject reported a strong urge to urinate, indicating maximum cystometric capacity. Any evidence of detrusor instability was recorded. Once maximum cystometric capacity was reached, the bladder catheter was removed and provocative stress maneuvers (Valsalva followed by cough) were performed. Provocative maneuvers were done first with the subject in the lithotomy position. If leakage did not occur, then provocative maneuvers were repeated in the standing position.

Clinical examination and urodynamic evaluation results determined continued study participation. Subjects were excluded from further participation if they recorded UUI episodes or less than one SUI episode on the 7-day baseline bladder diary. Likewise, they were excluded if they had vaginal wall prolapse beyond the vaginal introitus, an inability to demonstrate a palpable PFM contraction, sensory loss below the L4 dermatome, atrophic vaginitis or skin breakdown around the perineum (pre-

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\textsuperscript{‡} Rusch Inc, 2917 Weck Dr, Durham, NC 27709.
venting the use of a vaginal electromyographic [EMG] sensor), lumbosacral or pelvic pain or dysfunction that would interfere with PFM exercises, or the inability to tolerate the supine position. Exclusion on the basis of urodynamic findings occurred if a woman demonstrated detrusor instability or an abdominal leak point pressure of less than 60 cm of H2O. The urodynamic criteria minimized the chance that women with intrinsic sphincter deficiency or UUI would be included in the study.

**Study Outcome Measures**

Study outcome measures were obtained at the baseline and posttreatment examinations. Outcomes included frequency of incontinence episodes recorded on the bladder diary, urine leakage demonstrated during urodynamic testing, amount of urine leakage determined from a pad test, quality of life, and PFM strength.

**Bladder diary.** Subjects were provided a 1-week bladder diary before the baseline examination, at each physical therapy visit, and 1 week before the posttreatment examination. The 1-week bladder diary has been shown to have high test-retest reliability for diurnal and nocturnal micturition frequency and the number of incontinence episodes (r = .86–.91). Subjects recorded the time of each void and incontinence episode and the circumstances of each incontinence episode (eg, urgency, cough, or sneeze).

At baseline, average voiding frequency per day, the number of incontinence episodes per week, and the circumstances of each incontinence episode were extracted from the diary. Voiding frequency and the circumstances of each incontinence episode were reviewed to rule out the presence of urgency and UUI.

The number and circumstances of incontinence episodes were extracted from the bladder diary at the beginning of each physical therapy visit. This information was used by the physical therapist to guide exercise progression, to motivate the subject, and to educate the subject on strategies to prevent future SUI episodes. Data from the baseline and posttreatment diaries were used to determine pretreatment-to-posttreatment changes in the frequency of incontinence episodes.

**Urine leakage during urodynamic testing.** Urodynamic testing was performed at the baseline and posttreatment examinations by use of the procedure described earlier. Evidence of SUI and the coincident leak point pressure were recorded.

**Amount of urine leakage.** A modification of the 1-hour pad test recommended by the International Continence Society was used to quantify the amount of urine leakage. We chose this particular test because of its brevity and because it has been shown to have high test-retest reliability in women with SUI.

We administered the pad test at the baseline and posttreatment examinations immediately after urodynamic testing. We assumed that, in the absence of detrusor instability, urine loss would be minimal and the subject’s bladder still would be full. At the time of testing, the subjects were not menstruating, and any lubricant used for urodynamic testing was removed. A preweighed Depend Undergarment was worn by subjects to collect urine lost during the test. An Ohaus model CR 1200 Portable Advanced Scale was used to weigh the undergarment. The scale was calibrated before weighing of any pad. After subjects donned the pad, they were asked to walk 45 m (50 yd) at a comfortable pace. Subsequently, they performed the following provocative maneuvers 5 times: climbing a step, coughing, heel bouncing, and standing up from a sitting position. Finally, subjects placed their hands under running water for 1 minute. The undergarment was removed and weighed to determine urine loss.

**Quality of life.** Quality of life was measured with the Incontinence Impact Questionnaire (IIQ). The IIQ is a 30-item questionnaire designed to assess the effect of urinary incontinence across 4 domains: physical activity, travel, social relationships, and emotional health. The internal consistency, reproducibility, construct validity, and sensitivity of the IIQ were established for a population of community-dwelling women with SUI or UUI. Subjects completed the IIQ at the baseline and posttreatment examinations. Scores on the IIQ range from 0 to 400, with a higher score indicating poorer perceived quality of life.

**PFM strength.** Pelvic-floor muscle strength was examined through digital assessment and quantified by the method of Brink et al. The Brink scale considers 3 muscle function dimensions: muscle contraction duration, squeeze pressure felt around the examiner’s fingers, and vertical displacement of the examiner’s fingers as the PFMs contract. Each variable is rated separately on a 4-point categorical scale. The 3 subscale scores are summed to obtain a composite score ranging from 3 to 12. The interrater reliability, test-retest reliability, and validity of this strength assessment have been reported. Pelvic-floor muscle strength was assessed during the baseline and posttreatment examinations.

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**Intervention**

A recent review from the Cochrane Database of 22 studies examining the use of PFM exercises as an intervention for SUI concluded that studies are unclear and inconsistent with regard to PFM exercise variables, including whether or not daily practice is expected, the prescribed muscle contraction duration, and the number of muscle contractions prescribed per day. When evidence was found to support a particular PFM exercise variable, we integrated the evidence into the design of our intervention protocol. However, with regard to exercise progression, there was a lack of literature upon which to base our intervention protocol. Therefore, we devised an intervention protocol that could be individualized for each participant by progressing exercises with considerations for preventing muscle fatigue and enhancing exercise adherence.

The reviewed studies reported the most common PFM intervention length to be 12 weeks. To enhance the comparison of our results with those of other studies, we also selected a 12-week maximum intervention length. However, Dougherty et al. showed that women with SUI made the greatest improvements in both urine loss and muscle strength outcomes in the first 8 weeks of a 16-week PFM exercise intervention. On the basis of these findings, we implemented a 9- to 12-week intervention length with sessions conducted at 1-week intervals. A physical therapist determined the maximum number of visits based on an evaluation of subjects’ bladder diaries. If subjects were continent (no episodes of urine loss recorded on the bladder diaries) for 2 consecutive weeks by session 9, then they were scheduled for the post-intervention examination. Otherwise, subjects received 1 to 3 more visits until they recorded continence on the bladder diaries for 2 consecutive weeks. We defined a 3-minute rest interval was provided between each block (20 repetitions each) of the 3-second contraction. A 6-second rest interval followed each muscle contraction. Depending on fatigue, subjects performed 1 or 2 additional trial blocks (20 repetitions each) of the 3-second contraction. A 2- to 3-minute rest interval was provided between each block of contractions. We defined fatigue as a reduction in the subjects’ peak EMG over 3 consecutive contractions to below 50% of the average peak EMG demonstrated during the first practice block of 20 contractions. At the end of this visit, the therapist provided subjects with a home exercise program. The therapist also educated subjects with regard to PFM anatomy and physiology. The maximum exercise prescription at this visit was 20 repetitions (2 sets of 10) of the 3-second contraction provided the subjects did not demonstrate fatigue during practice. Otherwise, the number of repetitions prescribed equaled the average number of contractions the subjects performed in trial blocks 1 to 3. Subjects were instructed to perform their home exercise program twice a day.

For the 3-second maximum contraction, the therapist instructed subjects to “contract your PFM as quickly and as hard as you can; try to hold the contraction for the entire 3 seconds.” When accessory muscle activity from the gluteal or hip adductor muscles was observed, the therapist instructed the subjects to relax these muscles. Instruction to reduce abdominal muscle activity was given only if the subjects strained, causing the abdominal sensor to dislodge, or if abdominal muscle activity predominated over PFM activity. During this session, subjects performed 20 repetitions of the 3-second contraction over a 3-minute interval. A 6-second rest interval followed each muscle contraction. Depending on fatigue, subjects performed 1 or 2 additional trial blocks (20 repetitions each) of the 3-second contraction. A 2- to 3-minute rest interval was provided between each block of contractions. We defined fatigue as a reduction in the subjects’ peak EMG over 3 consecutive contractions to below 50% of the average peak EMG demonstrated during the first practice block of 20 contractions. At the end of this visit, the therapist provided subjects with a home exercise program. The therapist also educated subjects with regard to PFM anatomy and physiology. The maximum exercise prescription at this visit was 20 repetitions (2 sets of 10) of the 3-second contraction provided the subjects did not demonstrate fatigue during practice. Otherwise, the number of repetitions prescribed equaled the average number of contractions the subjects performed in trial blocks 1 to 3. Subjects were instructed to perform their home exercise program twice a day.

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* The Prometheus Group, One Washington St, Suite 303, Dover, NH 03820.
At the second intervention visit, the therapist inquired about the subjects’ ability to perform the home exercise program and reviewed the bladder diaries to enhance subjects’ awareness of any changes in their SUI episodes over the preceding week and to help them understand the precipitants of SUI. Using EMG biofeedback, subjects’ performance of the 3-second maximum contraction (with the same procedure as that outlined for intervention visit 1) was reevaluated. In addition, subjects were instructed to perform a 12-second PFM contraction. Constant tonic PFM activity contributes to pelvic organ support and prevents strain on pelvic ligaments and fasciae.26,27 Therefore, we included practice of a longer-duration contraction to promote PFM endurance capacity.25

For the 12-second contraction, subjects were instructed to “contract your PFM as hard as you can but focus on keeping the contraction as steady as you can for the 12 seconds.” The procedure for providing feedback to subjects regarding accessory muscle activity was the same as that outlined for intervention visit 1. Subjects practiced 10 repetitions of the 12-second contraction. A 24-second rest interval followed each muscle contraction. Depending on fatigue (as defined previously), subjects performed 1 or 2 additional trial blocks (10 repetitions each) of the 12-second contraction. A 2- to 3-minute rest interval was provided between each block of contractions. Then, the therapist revised the subjects’ home exercise program to include practice of the 3-second and 12-second contractions. The maximum exercise prescription at this visit was 20 repetitions (2 sets of 10) of the 3-second contraction and 10 repetitions (1 set) of the 12-second contraction. A 24-second rest interval followed each muscle contraction.

Reexamination and exercise progression at visits 4 to 12 followed the same procedures as those outlined for visit 3. The maximum exercise prescription at visit 4 was 30 repetitions (3 sets of 10) of the 3-second contraction and 30 repetitions (3 sets of 10) of the 12-second contraction performed twice daily. Otherwise, the number of repetitions prescribed per set equaled the average number of contractions the subjects performed in trial blocks 1 to 3 for each contraction type. Subjects again were instructed to perform their home exercise program twice a day. Exercise progression at this and all subsequent visits also depended on the subjects’ successful performance of the previous home exercise program. In addition, if a subject identified a barrier to exercise, then the therapist provided recommendations to minimize exercise barriers. For example, if a subject could not remember to exercise, then the therapist recommended linking exercise to another well-established behavior, such as brushing teeth or watching the evening news.

Like visit 2, the third intervention visit began with the therapist reviewing and discussing with subjects their bladder diaries, their home exercise program performance, and any exercise barriers they experienced. The subjects’ ability to perform the 3-second and 12-second contractions was reevaluated with the same procedures as those described for visit 2. At this session, subjects were randomized to either the supine or the combined supine-upright exercise progression. A block randomization schedule was determined with a random-number table. Five blocks with 10 assignments were created, with equal representation of both groups. Random assignment followed the block schedule, with the exception of balancing groups with regard to age (within 5 years) and incontinence severity (determined from the baseline bladder diary: minimal = <5 episodes per week, moderate=5–10 episodes per week, and severe=10 episodes per week). Subjects assigned to the supine group were advised to continue their exercises in the supine position. Subjects assigned to the combined supine-upright group were instructed to perform 1 set of each exercise (3- and 12-second contractions) in the supine, sitting, and standing positions. The maximum exercise prescription at this visit was 20 repetitions (2 sets of 10) of the 3-second contraction and 20 repetitions (2 sets of 10) of the 12-second contraction provided the subjects did not demonstrate fatigue during practice. Otherwise, the number of repetitions prescribed per set equaled the average number of contractions the subjects performed in trial blocks 1 to 3 for each contraction type. Subjects were instructed to perform their home exercise program twice a day. At this visit, the therapist instructed subjects to use the “stress strategy,”28,29 that is, to contract their PFM in anticipation of or during a cough or sneeze or any other activity that usually led to leakage. The therapist reinforced the use of the stress strategy at each subsequent visit during the bladder diary review.

Reexamination and exercise progression at visits 4 to 12 followed the same procedures as those outlined for visit 3. The maximum exercise prescription at visit 4 was 30 repetitions (3 sets of 10) of the 3-second contraction and 30 repetitions (3 sets of 10) of the 12-second contraction performed twice daily. Otherwise, the number of repetitions prescribed per set equaled the average number of contractions the subjects performed in trial blocks 1 to 3 for each contraction type. Subjects in the supine group performed all exercises in the supine position, whereas subjects assigned to the combined supine-upright group performed 1 set of exercises for each contraction type (3 seconds and 12 seconds) in the supine, sitting, and standing positions. From visits 5 to 12, the home exercise program continued to be progressed on the basis of the number of contractions performed in trial blocks 1 to 3 before the onset of fatigue for each contraction type. The maximum exercise prescription possible by visit 12 was 60 repetitions (3 sets of 20) of the 3-second contraction and 30 repetitions (3 sets of 10) of the 12-second contraction performed twice daily.
Posttreatment Examination
At the last intervention visit, subjects were given a posttreatment bladder diary to complete for 7 days before the posttreatment examination. The reexamination was scheduled within a 2-week period after the final intervention visit. During the reexamination, measurements for all study outcomes were obtained.

Data Analysis
To determine any baseline differences in age, number of urine leaks per week, and amount of urine loss on the pad test, groups were compared by use of independent t tests. Mann-Whitney U tests were performed to determine baseline group differences in IIQ and Brink scores. Baseline group differences in the proportion of women in each exercise group who experienced urine leakage during urodynamic testing were analyzed by use of chi-square analysis.

The effect of exercise position on intervention outcomes was determined by analyzing differences between preintervention and postintervention scores for bladder diary, pad test, quality-of-life, and PFM strength outcomes. This study applied an intention-to-treat analysis. Therefore, when a subject did not complete the study, her most recent bladder diary was used to calculate the preintervention-to-postintervention change in the number of urine leaks per week. Because pad test, quality-of-life, and PFM strength data were obtained only at baseline and postintervention evaluations, a zero change in values for these outcomes was entered for subjects not completing the study. Any group differences identified for baseline measures as statistically different or clinically important were adjusted for in the appropriate preintervention-to-postintervention outcome analyses.

A one-way analysis of variance was used to detect differences between the 2 groups in preintervention-to-postintervention reductions in the number of urine leaks per week and the amount of urine loss on the pad test. A Kruskal-Wallis one-way analysis of variance by ranks was used to detect group differences in preintervention-to-postintervention changes in IIQ and Brink scores. Postintervention exercise group differences in the proportion of women who demonstrated urine leakage during urodynamic testing were determined by use of chi-square analysis. The number of visits attended and the number of prescribed 3-second and 12-second contractions for both groups were compared by use of independent t tests.

When group assignment did not affect intervention outcomes, data from both groups were collapsed for further analysis. Baseline-to-postintervention changes in the number of urine leaks per week and the amount of urine loss on the pad test were analyzed by use of paired t tests. Baseline-to-postintervention changes in IIQ and Brink scores were analyzed by use of the Wilcoxon signed rank test. The McNemar test was used to test baseline-to-postintervention changes in the distribution of women who did and women who did not have urine leakage during urodynamic testing.

To summarize the effectiveness of PFM exercises in improving continence, a percentage of reduction in incontinence episodes determined from the pretreatment and posttreatment bladder diaries was calculated for each subject with the following formula: [(pretreatment – posttreatment number of incontinence episodes)/pretreatment number of incontinence episodes] × 100. In addition, the percentages of reduction in scores were averaged to obtain an overall percentage of reduction in incontinence episodes for the entire sample of women.

Results
Subjects
Eighty women were screened for study eligibility. Forty-six women were eligible for participation; however, at the pretreatment examination, 1 woman demonstrated detrusor instability during urodynamic testing and another woman recorded episodes of UUI on her baseline bladder diary. Therefore, only 44 women continued into the study’s intervention phase. The mean age of the 44 women was 52.6 years (SD = 8.5 years). The median parity was 2, and 57% of the sample was postmenopausal. Forty-one women were white, 2 were African American, and 1 was Asian. Twenty-two women were randomly assigned to each treatment group.

Baseline measures for subjects in both groups are shown in Table 1. Before the intervention, there were no statistically significant differences between groups with respect to age, number of urine leaks per week, amount of urine loss on the pad test, IIQ scores, or Brink scores (all P values > .05). Although not statistically significant, there was a trend for a larger amount of baseline urine loss on the pad test for women assigned to the combined supine-upright exercise group. This result caused us to adjust for baseline urine loss on the pad test in subsequent preintervention-to-postintervention bladder diary and pad test analyses.

The percentage of women in each group who had urine leakage during urodynamic testing at baseline, demonstrating urodynamic stress urinary incontinence (USUI), also is shown in Table 1. Urodynamic stress urinary incontinence was diagnosed in 59% of the entire study cohort. There was no difference in the prevalence of USUI between the exercise groups at baseline.
Table 1.  
Group Comparisons at Baseline for Mean Age, Urine Leaks, Urine Loss, Incontinence Impact Questionnaire Score, and Brink Score and for the Prevalence of Urodynamic Stress Urinary Incontinence (USUI)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value for:</th>
<th>Supine Group</th>
<th>Supine-Upright Group</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y, X±SD (range)</td>
<td></td>
<td>51.7±8.9 (39–68)</td>
<td>53.6±8.1 (39–68)</td>
<td>.42</td>
</tr>
<tr>
<td>Urine leaks/wk, X±SD (range)</td>
<td></td>
<td>6.9±7.0 (1.0–28.0)</td>
<td>7.2±5.5 (1.0–21.0)</td>
<td>.86</td>
</tr>
<tr>
<td>Amount of urine loss on pad test, g, X±SD (range)</td>
<td></td>
<td>4.0±5.2 (0.0–18.6)</td>
<td>11.7±27.7 (0.0–120.5)</td>
<td>.22</td>
</tr>
<tr>
<td>Incontinence Impact Questionnaire score, X±SD (range)</td>
<td></td>
<td>54.9±54.6 (0.0–208.0)</td>
<td>54.4±53.8 (0.0–187.0)</td>
<td>.99</td>
</tr>
<tr>
<td>Brink score, X±SD (range)</td>
<td></td>
<td>8.6±2.2 (5.0–12.0)</td>
<td>8.4±2.4 (3.0–13.0)</td>
<td>.89</td>
</tr>
<tr>
<td>Prevalence of USUI, no. (%)</td>
<td></td>
<td>12 (54.5)</td>
<td>14 (63.6)</td>
<td>.54</td>
</tr>
</tbody>
</table>

Table 2.  
Effects of Exercise Position on Changes in Urine Leaks, Urine Loss, Incontinence Impact Questionnaire Score, and Brink Score and on the Prevalence of Urodynamic Stress Urinary Incontinence (USUI) After Intervention

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value for:</th>
<th>Supine Group</th>
<th>Supine-Upright Group</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in urine leaks/wk, X±SD (range)</td>
<td></td>
<td>4.0±4.7 (–4.0 to 18.0)</td>
<td>5.4±4.8 (0.0 to 16.0)</td>
<td>.30</td>
</tr>
<tr>
<td>Change in amount of urine loss on pad test, g, X±SD (range)</td>
<td></td>
<td>3.9±3.8 (–2.7 to 11.4)</td>
<td>5.1±3.9 (–7.1 to 102.0)</td>
<td>.29</td>
</tr>
<tr>
<td>Change in Incontinence Impact Questionnaire score, X±SD (range)</td>
<td></td>
<td>27.6±32.7 (0.0 to 135.0)</td>
<td>24.7±31.0 (–22.3 to 85.5)</td>
<td>.62</td>
</tr>
<tr>
<td>Change in Brink score, X±SD (range)</td>
<td></td>
<td>2.0±1.7 (0.0 to 5.0)</td>
<td>2.2±1.9 (0.0 to 6.0)</td>
<td>.75</td>
</tr>
<tr>
<td>Prevalence of USUI, no. (%) of subjects</td>
<td></td>
<td>9 (40.9)</td>
<td>9 (40.9)</td>
<td>1.0</td>
</tr>
</tbody>
</table>

*As the mean value increases, indicators of incontinence, quality of life, and muscle strength improve.

Baseline-to-Postintervention Changes in Outcome Measures

Baseline-to-postintervention changes in bladder diary, pad test, quality-of-life, and PFM strength outcomes are shown by exercise group in Table 2. Reductions in the number of urine leaks per week and the amount of urine loss during the pad test were not statistically different between the exercise groups. Likewise, there were no statistically significant differences in improvements in IIQ or Brink scores. Table 2 also shows the prevalence of USUI postintervention by exercise group. The prevalence of USUI decreased to 41% for the entire study cohort. Exercise position did not have an impact on the prevalence of USUI postintervention between the exercise groups.

Five (22.7%) of the women assigned to the supine exercise group and 3 (13.6%) of the women assigned the combined supine-upright exercise group dropped out of the study. The number of visits attended did not differ by exercise group. Including data for dropouts, means for the number of visits attended were 8.4 (SD=2.8, range=2.0–12.0) and 8.9 (SD=3.0, range=1.0–12.0) for the supine and combined supine-upright exercise groups, respectively (P=.53). For those who completed the trial, means for the number of visits attended were 9.88 (SD=1.11, range=9.0–12.0) and 10.16 (SD=1.01, range=9.0–12.0) for the supine and combined supine-upright exercise groups, respectively (P=.42). The numbers of exercises prescribed by the therapist did not differ between the exercise groups. Means for the prescribed number of 3-second contractions were 75 (SD=32.5) and 81 (SD=32) for the supine and combined supine-upright exercise groups, respectively (P=.52). Means for the prescribed number of 12-second contractions were 50 (SD=16.3) and 50 (SD=14.7) for the supine and combined supine-upright exercise groups, respectively (P=.96).

Because exercise position did not affect intervention outcomes, we collapsed data from both groups for further analysis. The baseline-to-postintervention comparisons of the number of urine leaks per week, amount of urine loss on the pad test, IIQ scores, and Brink scores are shown in Table 3. This sample of women demonstrated a statistically significant reduction in the number of urine leaks per week, as reported on the bladder diary, from baseline to postintervention evaluations.

The amount of urine lost during the postintervention pad test decreased from that at baseline; however, this change did not reach statistical significance. Statistically significant improvements in IIQ and Brink scores were observed after intervention (Tab. 3). Table 3 also shows the prevalence of USUI for all women before and after intervention. We found a statistically significant reduction in USUI prevalence following intervention. The
The percentage of reduction in incontinence episodes documented in the preintervention and postintervention bladder diaries for the entire group of women is shown in the Figure. Almost 41% of the women experienced a 100% resolution of their SUI symptoms, and another 20.5% experienced at least a 75% reduction in their symptoms. Overall, the women in this study achieved a mean 67.9% reduction in the frequency of incontinence episodes as a result of treatment. For treatment efficacy purposes, the percentage of reduction in incontinence episodes also was examined for the 36 women who completed the trial. The mean reduction in the frequency of incontinence episodes for these women was 78.8%.

Discussion

Our hypothesis that women who had SUI and who performed PFM exercises in both supine and upright positions would obtain better treatment outcomes than women who exercised in the supine position only was not supported. These results were surprising, as they appear to disagree with current training specificity theory, which suggests that greater gains in motor performance occur when practice most closely approximates task or functional requirements. In addition, they seem to be inconsistent with the results of studies related to enhancing muscle strength and performance, which do support training specificity theory. Experimental evidence has shown that improvements in muscle performance are specific to training velocity and muscle length or training angle. The importance of posture specificity in muscle training also has been shown. Exercise position did not affect outcomes in this study. This finding may be attributed to our focus on continence outcomes and not on specific muscle force and timing outcomes. In addition, we measured muscle strength by digital examination with the subject lying supine. Although the exercise groups achieved similar PFM strength gains, this finding should be interpreted within the limitations imposed by the testing method and position.

Our findings suggest that other exercise variables may be more critical than position in enhancing urinary continence outcomes. For instance, contraction duration, rate of force production, or the number of contractions prescribed may be of equal or greater importance. The exercise protocol used in this study applied the concept of muscle loading by increasing the number of muscle contractions performed. The number of prescribed muscle contractions in our protocol was higher than that reported in other studies. Although the numbers of contractions performed by women in our study did not differ between exercise groups, it is plausible that the high contraction repetition provided a mechanism for increasing muscle function that was not enhanced further by changing exercise position.
In addition, it is possible that women did not adhere to their assigned exercise position, diluting group outcome differences. We did not formally track participants’ adherence to the assigned exercise position. However, at each study visit, we reinforced with women the importance of exercising only in their assigned position. Reasons can be hypothesized for why either group may have deviated from the assigned protocol. Women assigned to the supine-only exercise group may have exercised in the upright position for the sake of convenience. Women assigned to the combined supine-upright exercise group may have exercised in the supine position because they believed it was less fatiguing. Therefore, we believe that if nonadherence occurred, it did so with similar frequencies across groups, thus not biasing outcomes.

The focus of our treatment protocol was not limited to enhancing PFM strength and endurance. Women in our study were taught to use the stress strategy to prevent urine leakage by contracting their PFMs in anticipation of a cough, sneeze, or other activity that precipitated a SUI incident. This skill depends not only on muscle strength but also on the ability to anticipate the SUI event and properly time the muscle contraction. From a functional perspective, practice of voluntary PFM contractions to occlude the urethra and prevent urine loss is critical. Therefore, we made the decision to teach both groups of women to use the stress strategy to prevent urine loss. As a result, some opportunity to exercise in upright positions was afforded to the group of women assigned to exercise in the supine position. We cannot dispute the possibility that this opportunity may have reduced our chances of finding different outcomes for women assigned to the 2 exercise groups. Regardless, women in the combined supine-upright exercise group had significantly greater practice using their muscles in upright positions than did women in the supine-only exercise group. Therefore, if exercise position was a critical exercise variable, we believe that group differences in continence outcomes should have been observed.

From a task difficulty standpoint, PFM exercises in upright positions should be more difficult to perform than exercises in the supine position, as forces acting on the PFMs increase. Recently, Morgan et al found that bladder pressure at rest and during maximum voluntary PFM contraction was greater when continent women were standing than when they were lying down. In addition, they observed that most women could not contract their PFMs in a standing position without a concomitant increase in intra-abdominal pressure. In our study, several women indicated that they had greater difficulty knowing whether they were exercising correctly in the standing position. Likewise, many women indicated that exercises performed in the standing position were more fatiguing than those performed in the supine or sitting position. A woman who is unsure whether she is exercising correctly or is experiencing exercise-associated fatigue may be less likely to adhere to her exercise regimen. In this context, our findings are clinically significant because they allow a clinician greater flexibility in exercise prescription. On the basis of our data, a decision to have such a woman continue her exercise progression in the supine position should not compromise her continence outcomes.

Limitations in our study design may have lessened our ability to find differences between exercise interventions (supine only versus combined supine-upright). Most of the clinical outcomes were collected by the treating therapist. Only the urodynamic data were obtained by a clinician unaware of the assigned intervention group: the nurse practitioner. We believe that the threat of therapist bias was greatest for PFM strength outcomes, as it required the physical therapist to evaluate examination findings when assigning the Brink score. The statistical power to detect a difference in the reduction of urine leaks per week between women who exercised in the supine position only and women who exercised in the combined supine-upright positions was low (18%) and also should be considered a possible limitation in interpreting the results of this analysis.

Our results add to the body of evidence that supports the use of PFM exercises as an effective intervention for women with SUI. About 41% of the women in our study experienced a 100% reduction and 20.5% experienced at least a 75% reduction in the number of SUI episodes per week. The intention-to-treat analysis revealed that women who participated in our study achieved a mean 67.9% reduction in the frequency of SUI episodes. An even greater reduction in symptoms, a mean 78.8% reduction, occurred in women who completed the trial.

Differences in exercise protocol and study outcome measures impose some limitations on direct comparisons of our results with the results of other studies. However, our results are most similar to those reported by Goode et al. Their intention-to-treat and efficacy results revealed 68.6% and 80.2% reductions in incontinence episodes reported on bladder diaries for women with predominant SUI symptoms, respectively. In addition, women in both studies obtained statistically significant improvements in quality of life after treatment, as measured by the IIQ. The studies differ, however, in the percentages of women who reported a 100% reduction in incontinence episodes. Goode et al reported that less than 20% achieved a 100% reduction in incontinence episodes; in contrast, 41% of the women in our study became continent.
Our results appear to be much better than those reported by Wyman et al\textsuperscript{37} for a subgroup of women who had SUI and who participated in a 12-week intervention program including biofeedback training. From baseline to posttreatment evaluations, women in the study of Wyman et al\textsuperscript{37} showed about a 43% reduction in the number of incontinence episodes per week (from $15.3 \pm 14.5$ [X$\pm$SD] at baseline to $8.7 \pm 0$ [X$\pm$SD] after treatment). Additional data presented by Wyman et al\textsuperscript{37} detailing the percentage of reduction in incontinence episodes achieved posttreatment included women with SUI only and women with detrusor instability (with or without concomitant SUI). Thirteen percent of subjects achieved a 100% reduction in incontinence episodes, an equal number reported a 75% to 99% reduction, and 31% experienced a 50% to 74% reduction in incontinence episodes following treatment. Our cure and improvement rates also were higher than the 16% cure rate and the 44% improvement rate (50%–99% reduction in urine loss per week) reported by Burns et al.\textsuperscript{9} On the basis of a self assessment of their perceived condition, 56% of women treated with PFM exercises in a study by Bo et al\textsuperscript{10} indicated that their SUI was “unproblematic” following treatment. If “unproblematic” meant “continent,” then our cure rate would be lower than that reported by Bo et al.\textsuperscript{10} However, an additional self-assessment of cure or improvement in SUI symptoms showed that 8%, 40%, and 44% of the women indicated that they were continent, almost continent, and improved, respectively.\textsuperscript{10}

We hypothesize that the higher cure rate obtained in our study than in other studies\textsuperscript{9,10,12,37} may be attributed to differences in subject characteristics and exercise prescription. The studies by Burns et al\textsuperscript{9} Goode et al\textsuperscript{12} and Wyman et al\textsuperscript{37} included women with more severe SUI at baseline (the mean number of incontinence episodes per week ranged from 15.1 to 18) than that of the women in our study. Given the difference in symptom severity, it is not surprising that a higher cure rate was obtained in our study. However, the baseline incontinence severity in the study of Bo et al\textsuperscript{10} was lower (2.0±1.8 [X$\pm$SD] incontinence episodes over a 3-day period) than that in our study.

Lower cure rates also may be expected from comparison studies that included women with mixed urinary incontinence.\textsuperscript{9,12,37} However, as in our study, subjects in the study of Bo et al\textsuperscript{10} were excluded if they had urinary incontinence other than genuine stress incontinence. Therefore, we believe that discussion of the similarities and differences between our exercise protocol and those of the comparison studies may provide additional insight into the observed outcome differences.

We do not believe that treatment duration differences played a significant role. With the exception of the 6-month intervention in the study of Bo et al,\textsuperscript{10} treatment durations were comparable, ranging from 8 to 12 weeks. Although the comparison studies used methods slightly different from those that we used, we believe that the regimens in the comparison studies also were designed with the purposes of improving PFM endurance capacity and ability to prevent urine leakage during a sudden rise in abdominal pressure. All of the comparison studies included practice of a long-duration PFM contraction (at least 8 seconds)\textsuperscript{9,10,12,37} In addition, Burns et al\textsuperscript{9} and Wyman et al\textsuperscript{37} also recommended that their subjects perform a fast (3-second) contraction, and Bo et al\textsuperscript{10} instructed their subjects to add 3 or 4 fast PFM contractions after each sustained contraction. Goode et al\textsuperscript{12} used a 10-second PFM contraction but also taught women the stress strategy, which provided their subjects an opportunity to practice quick, forceful contractions.

One difference in our exercise protocol, the larger number of PFM contractions prescribed, may have contributed partially to our higher cure rate. Goode et al\textsuperscript{12} instructed women to perform 15 PFM contractions 3 times per day. The maximum daily number of contractions performed by subjects in the study of Wyman et al\textsuperscript{37} was 50. Bo et al\textsuperscript{10} also prescribed far fewer contractions, 8 to 12 contractions 3 times per day. Our higher maximum exercise dose may have allowed for more opportunity to promote strength and endurance through continued progressive muscle loading. However, Burns et al exceeded our maximum exercise prescription, advising subjects to perform 200 PFM contractions per day.\textsuperscript{9} Therefore, we hypothesize that our method of individualizing exercise prescription also may have contributed to our higher cure rate. Although most of the trials stated or implied that exercise repetitions progressed to a maximum number,\textsuperscript{9,12,37} the criteria upon which exercise progression was based were less clearly defined. We used data from the biofeedback session regarding muscle fatigue and from the women regarding their ability to perform the home exercise program to guide exercise prescription. Increasing exercise intensity without regard to limits imposed by a patient’s musculoskeletal system and lifestyle runs the risk of nonadherence. Until studies undertake the difficult task of determining the optimal PFM exercise intensity and method for exercise progression for SUI, we believe that an approach that considers a patient’s muscle function and ability to successfully perform a home exercise program, along with adequate progressive muscle loading, may be most prudent.

Although the exercise protocol used in this study was found to be effective in reducing SUI, generalization of the results is limited. The majority of women in this study
had mild to moderate SUI, no urgency symptoms or urge incontinence, and no previous SUI treatment. The number of leaks per week at baseline for the entire sample was $7.0 \pm 6.2$ ($\overline{X} \pm SD$). Our sample also demonstrated a baseline Brink score of $8.5 \pm 2.3$ ($\overline{X} \pm SD$), indicating a substantial ability to contract PFM before treatment. Women with more severe incontinence, mixed incontinence, prior treatment failures, or weaker baseline PFM strength should not be expected to achieve comparable outcomes.

We believe that the women recruited into this study were highly motivated. The attrition rate for the entire sample of women was only 18.6%, and the majority of women who left the study did so early on ($3.3 \pm 1.9$ [$\overline{X} \pm SD$] visits). The most common reason for attrition was the inability to attend visits because of work. We believe that the low attrition rate is remarkable given the subject burden associated with this study.

Women completing our intervention trial received $9.8 \pm 1.3$ ($\overline{X} \pm SD$) visits with the physical therapist. We recognize that the number of physical therapy visits reimbursed by third-party payers may be smaller. However, to completely test the efficacy of our protocol, we wanted women to have the opportunity to reach stable progress before their discharge. In addition, we aimed to reduce exercise barriers by monitoring the women on a weekly basis. Therefore, the 78.8% reduction in incontinence episodes achieved by women completing the protocol may not be generalizable to situations with fewer visits and less monitoring by a physical therapist.

**Conclusion**

With regard to prescription of PFM exercises for women with SUI, several exercise variables can be manipulated, including the number of contractions performed per day, the duration of muscle contraction, the muscle contraction/rest ratio, and the exercise position. On the basis of data from this study, exercise position does not affect incontinence outcomes in a cohort of women who also are taught a preemptive stress strategy. Women who performed PFM exercises in both the supine and the upright positions did not obtain better continence outcomes than did women who exercised in the supine position only. These findings allow a clinician to approach exercise prescription with greater flexibility.

Along with data from other studies, our data support the efficacy of using PFM exercises as an intervention for management of female SUI. Women who completed the trial achieved a mean 78.8% reduction in SUI episodes. In addition, PFM exercises resulted in gains in quality of life and PFM strength and a reduction in urine leakage during urodynamic testing.

**References**


