The Effect of Commonly Performed Exercises on the Levator Hiatus Area and the Length and Strength of Pelvic Floor Muscles in Postpartum Women

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Objective: The aim of his study was to compare the effects of 10 common exercises to traditional pelvic floor muscle (PFM) contractions (Kegel) on levator hiatus (LH) area and PFM length and strength.

Methods: This is a cross-sectional study of 15 healthy postpartum women. Ten exercises were studied. These were common variations of leg, core, and back exercises used in yoga, Pilates, strength training, and physical therapy. Each participant performed all 10 exercises at a single visit in 2 examination settings: transperineal ultrasound and perineometry. Ultrasound measured the LH area and PFM length, and perineometry measured the muscle strength (peak squeeze pressure).

Results: Kegel generates an increase in squeeze pressure (24.3 cmH2O), shortens the muscles (−0.46 cm) and narrows the LH (−0.13 cm2). The bird-dog and plank exercises were not different from Kegel in any measurement. While the leg lift-ultrasound dimensions were similar to Kegel, leg lifts generated peak squeeze pressures stronger than any other exercise (including Kegel). Whereas ultrasound dimensions were similar to Kegel, tucked and untucked squats and thigh adductions generated weaker contractions than Kegel. While crunch generated a squeeze pressure similar to Kegel, the ultrasound dimensions showed a significantly wider LH and longer muscle than Kegel. Bridge, clam, and pile exercises affected the PFM differently than Kegel in all measures.

Conclusions: Bird-dog, plank, and leg-lift exercises should be evaluated as alternative exercises to Kegel as they affect PFM strength and length and LH area similarly to Kegel, and leg lifts generate a stronger contraction than Kegel.

Key Words: pelvic floor muscle exercise, perineometry, Pilates, transperineal ultrasound, yoga.

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Kegel, as early as 1948, asserted that women with stress incontinence lack awareness and coordination of PFM and that stress uri-nary incontinence, pelvic relaxation, and sexual dysfunction could be resolved with PFM training. Although a variety of physiotherapy methods have been shown in clinical research trials to be effective, the effect in clinical practice often appears modest, because of a number of barriers to implementation in the general population. The barriers are broad and include problems with patient awareness and education, disagreement about correct techniques, and issues of compliance and motivation.

Even if a woman has pelvic floor symptoms and is aware of the problem, she may find it difficult to do the exercises correctly herself. Kandadai et al reported a study of 250 eligible females: 24% of them were unable to correctly perform the pelvic floor exercises initially. Of the participants who reported current practice of pelvic muscle exercises, 23% of them performed the exercise incorrectly.

Overcoming the barriers of education, awareness, technique, and compliance is a formidable task. We believe that identifying commonly performed exercises that can also effectively activate the pelvic muscles, even if the patient is not aware, would be an important contribution. Exercises are particularly intriguing if they provide additional benefits such as overall body strength, tone, and flexibility.

The goal of this study was to identify which exercises primarily or secondarily activate pelvic floor musculature. Our primary aim was to compare the effect of 10 common exercises versus traditional PFM contractions (Kegels) on the levator hiatus (LH) area, the PFM length, and PFM strength. We hypothesized that common exercises will constrict the LH and PFM length and increase PFM strength more effectively than the traditional PFM contraction.

MATERIALS AND METHODS

This is a cross-sectional study of healthy parous women describing the effects of 10 common exercises on the LH area and length and strength of the PFM compared with rest and Kegel PFM contractions. Institutional review board approval for the study was obtained. Women who were at least 18 years old and who were 6 months to 2 years postpartum were recruited for the study at a single tertiary care referral center. We assumed that these postpartum women would likely have incurred some degree of damage to the PFM with their recent pregnancy and delivery but allowed 6 months for regression to mean PFM strength and function.

Women who were currently pregnant, had pelvic organ prolapse beyond the hymen, were immobile, required assistance for ambulation, or had neurologic/functional disease or pain that precluded them from performing exercise poses or pelvic floor contractions were excluded.

Several studies highlight the importance of identifying, isolating, and strengthening the transverse abdominal muscles, multifidus muscles, and PFM including the levator ani in order to successfully strengthen the pelvic floor and provide symptomatic improvement of PFD. Brubaker and Kotarios reported that the exercise most associated with facilitation of the pelvic floor musculature is...
extension, adduction, and external rotation of the lower extremities. These principles shaped the exercises tested in this study. The 10 exercises studied included bird dog, bridge, clam, crunch, tucked squat, untucked squat, leg lift, plank, plié, and thigh adduction. The full description of the exercise techniques is described in Appendix A (Supplemental Digital Content 1, http://links.lww.com/FPMRS/A62). These exercises were chosen because they are commonly performed and are familiar to most women. The regimen of exercises was reviewed by an expert pelvic floor physical therapist for feasibility, safety, and efficacy.

Group instruction has been shown to be effective in improving pelvic floor strength. Therefore, small groups of participants were taught to perform 10 exercises aimed at engaging the pelvic floor and increasing flexibility and strength. These were taught by a single expert certified yoga instructor. A script was followed for initial introduction to all participants, which was approved by a certified pelvic floor physical therapist, but the instructor was also able to individualize instruction for women who had questions or difficulty.

Participants were then examined in 3 settings: digital examination, perineometry, and transperineal ultrasound. Each examination setting was run by a single, blinded assessor (either a fellow or attending in urogynecology), with that physician performing all ultrasound, perineometry, or Brinks measurements in the study. The assessor was blinded to results of other examinations, as well as the participants’ demographic information, obstetric history, survey results, or symptoms. During the physician-led examinations, when describing contraction of the pelvic floor, we used the phrase “Squeeze the vaginal muscles you use to hold your urine.” This phrase has been shown to result most often in correct performance. During the examinations, all women were instructed by the same provider on the proper form of each exercise and that provider verified correct performance for all women. The 3 examinations as well as the specific order of exercises within each examination were randomized.

A digital assessment of PFM contraction was measured by the Brink scale. All 10 exercises as well as Kegel and rest were performed while measurements were taken in the 2 subsequent examination settings: perineometry and transperineal ultrasound were performed during each exercise. Pelvic floor muscle strength was measured by the Peritron perineometer (NEEN HealthCare, East Dereham, Norfolk, United Kingdom). It is an advanced pressure biofeedback device specifically designed for pelvic floor assessment. We inserted the perineometer into the vagina, zeroed the device, and then instructed the participant to perform a Kegel PFM contraction and each of the 10 exercises in random order. Two repetitions of each maneuver were performed, and the mean peak squeeze amplitude was reported. Careful examination was performed to monitor for Valsalva during these maneuvers and correct the participant’s form if this was noted. Both the perineometer and Brink scale show good interrater and intrarater reliability and have similar levels of reproducibility. The perineometer has good test-retest reliability in premenopausal and postmenopausal women, in parous and nulliparous women, and women with and without pelvic organ prolapse or incontinence.

For the ultrasound examination, the participant was instructed to rest, perform a PFM contraction, and perform 10 familiar exercises in random order. Transperineal ultrasound was performed during each maneuver using a GE Voluson E6 (GE Healthcare Ultrasound; GE Healthcare, Chicago, IL) and a 3.9-MHz transducer with an 85-degree acquisition angle at 2 to 3 Hz 13. For rest and the PFM contraction, the subject was examined in the lithotomy position. Otherwise, the subject was examined in the most accessible, reproducible position during each individual exercise.

The transperineal transducer was placed over the labia. It was then adjusted to obtain a 2-dimensional sagittal image that encompassed the symphysis pubis, urethra, bladder, vagina, anorectal junction, and the back sling of the puborectalis muscle. The symphysis pubis was the primary landmark located to the left of the image. The examiner moved freely with the participants in order to ensure a reproducible angle of the transducer over the labia to capture the aforementioned landmarks. The images were frozen at the same point in time during the exercise for every participant (eg, at the top of a plié or the height of a crunch). The images were selected only if all of the structures were clearly visible. Once an adequate image was captured in the 2-dimensional view, they were rendered into 3-dimensional images.

All image volume data sets obtained were stored, and measurements taken offline. A single-blinded individual obtained the ultrasound images. The ultrasound measurements were then taken from the images by 2 blinded assessors (each assessor took 2 measurements, and their means were compared). Measurements were taken in the axial plane of minimal hiatal dimensions. This plane is identified as the minimal distance between the hyperechogenic posterior aspect of the pubic bone and the hyperechogenic anterior border of the puborectalis muscle at the anorectal angle. The 4 measurements taken were (1) the LH anterior-posterior diameter; (2) the LH transverse diameter; (3) the area of LH, measured as the area bordered by the pubovesical muscle, symphysis pubis, and inferior pubic ramus; (4) the PFM length, calculated as circumference of the LH minus the suprapubic arch (Fig. 1). Interrater reliability was tested with Bland-Altman analyses for each of the 4 measurements. Other data captured included demographic information and quality-of-life survey responses. We also collected patient assessment and Ease of Performance Likert scales (see Appendix B, Supplemental Digital Content 1, http://links.lww.com/FPMRS/A62).

Data were managed and analyzed using JMP Pro version 12.0 or SAS (SAS Inc, Cary, NC). Descriptive statistics were used to characterize the overall population. Mean change in peak squeeze pressures, change in LH area, and change in PFM length compared measurements of each maneuver to those taken at rest to obtain a difference. These mean differences were then compared with those of Kegel PFM contractions using paired Wilcoxon signed rank tests. \( P \leq 0.05 \) was considered statistically significant. Positive differences represent higher squeeze pressure, wider area, and longer length than Kegel, whereas negative values are lower squeeze pressure, narrower area, and shorter length versus Kegel.

Sample size calculation using our primary outcome of reduction in LH area is based on published literature. In a study comparing the effect of transverse abdominis muscle contraction on PFM (looking for co-contraction of transverse abdominis and LH), Bo et al assumed 25% reduction in LH area for PFM contraction based on study of healthy volunteers. They then considered a 50% change to this reduced LH area to be clinically relevant. Using \( \alpha = 0.05 \) and power of 0.80, the sample size was 13. To allow for possible exclusion due to inability to activate PFM, we decided to recruit 15 participants.

RESULTS

Fifteen women participated in this study. Baseline characteristics of the population are presented as medians (ranges) and are as follows: age, 32 (28–39) years; BMI, 25 (19–40) kg/m2; parity, 2 (1–3); time from delivery, 15 (9–29) months; and weight of last infant, 7.6 (6.3–8.9) lb (Table 1). No women had a history of third- or fourth-degree perineal lacerations, and all women had practiced Kegels in the past, but only 20% (3/15) were currently performing them. Median Brinks scale score was 9, with a range of 7 to 12, indicating moderate PFM strength. Twenty-seven percent (4/15) of women did not exercise at all, 13% (2/15) exercised “occasionally,” 20% (3/15) exercised once per week, 33% (5/15) exercised 2 to 3 times per week.
times per week, and 7% (1/15) exercised 4 to 5 times per week. Among those who exercised, 60% (9/15) did “cardio,” that is, running, walking, elliptical, and so on. Twenty-seven percent (4/15) did “weight lifting,” 27% (4/15) did yoga, none did Pilates, and 13% (2/15) participated in group exercise classes. Participants were allowed to choose more than 1 type of exercise.

Table 2 demonstrates the data for perineometry PFM strength, ultrasonographic changes in LH area, and PFM length from rest. Kegel generates an increase in squeeze pressure (24.3 cm H2O), shortens the PFM (−0.46 cm), and narrows the LH area (−0.13 cm2) compared with rest.

When comparing our perineometry outcomes, 3 exercises (bird dog, crunch, and plank) generated similar peak squeeze pressures to Kegel (median squeeze pressures ranging 14–19.9 cm H2O, mean differences ranging −1.2 to −7.2 cm H2O, and P values ranging 0.06–0.42). One exercise (leg lift) generated peak squeeze pressure significantly higher than Kegel (median squeeze pressure of 52.7 cm H2O, mean difference of 25.2 cm H2O). Leg lifts also generated higher squeeze pressures than all other exercises as well. Six exercises (bridge, clam, tucked squat, untucked squat, plié, and thigh adduction) generated significantly lower squeeze pressures than Kegel (median values ranging 6.1–12.4 cm H2O, mean differences ranging −14.9 to −5.2 cm H2O weaker than Kegel, and P values ranging 0.0006–0.03).

When comparing our ultrasound measurements, 6 exercises (bird dog, tucked squats, untucked squats, leg lifts, plank, and thigh adduction) affected the LH area similar to Kegels (median change in area ranging −0.9 to 0.8 cm2, mean differences ranging −0.4 to 1.3 cm2, and P values ranging 0.06–0.64). Four exercises (bridge, clam, crunch, and plié) created wider LH than Kegel, with median change in area ranging from 0.1 to 3 cm2 (mean differences ranging 1.7–2.9 cm2 wider than Kegel, with P values ranging 0.04 to 0.0009).

A representative example of the Bland-Altman plots for intrarater reliability is provided in Figure 2. Both the Pearson correlation coefficients (r) and the intraclass correlation coefficients (ICCs) between raters were high in all 4 measurements, suggesting strong correlation and excellent intrarater reliability. For LH anterior-posterior diameter, r = 0.75 and ICC = 0.85. For LH transverse diameter, r = 0.80 and ICC = 0.89. For LH area, r = 0.88 and ICC = 0.94, and for PFM length, r = 0.93 and ICC = 0.96.

At the conclusion of the visit, participants were asked to complete a survey characterizing their experiences with PFM exercises as well as the 10 tested exercises. Only 27% (4/15) had ever previously received feedback on PFM exercises (from an obstetrician-gynecologist, 1 nurse, and 2 physical therapists). Every participant had performed at least “a few” of the exercises before. Sixty percent (9/15) had performed a “few” of them, and 40% (6/15) had performed “many,” “most,” or “all” of them. Only 33% (5/15) of participants had done these 10 common exercises specifically to strengthen the pelvic floor. Reasons cited for prior performance of the common exercises were 60% (8/15) for meditation/relaxation, 53% (8/15) for toning, 40% (6/15) for general muscle building, 27% (4/15) for weight loss, 6% (1/15) for flexibility, and 6% (1/15) for correction of abdominal diastasis.

Table 1. Demographic Variables of Participants

<table>
<thead>
<tr>
<th>Variables</th>
<th>Median Values (Range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td>32 (28–39)</td>
</tr>
<tr>
<td>Parity, n</td>
<td>2 (1–3)</td>
</tr>
<tr>
<td>BMI, kg/m²</td>
<td>25 (19.40)</td>
</tr>
<tr>
<td>Race, % (n)</td>
<td>93 (14)</td>
</tr>
<tr>
<td>Smoking status, % (n)</td>
<td>7 (1)</td>
</tr>
<tr>
<td>Previous smoker</td>
<td>27 (4)</td>
</tr>
<tr>
<td>Never smoker</td>
<td>73 (11)</td>
</tr>
<tr>
<td>Birth weight of last baby, lb</td>
<td>7.6 (6.3–8.9)</td>
</tr>
<tr>
<td>Months since last delivery</td>
<td>15 (9–29)</td>
</tr>
<tr>
<td>History of 3rd- or 4th-degree perineal laceration, n</td>
<td>0</td>
</tr>
<tr>
<td>Brinks scale score</td>
<td>9 (7–12)</td>
</tr>
<tr>
<td>Exercise</td>
<td>Median Perineometer PFM Strength (Range)</td>
</tr>
<tr>
<td>---------------</td>
<td>----------------------------------------</td>
</tr>
<tr>
<td>Bird dog</td>
<td>18.4 (5.7 to 56.9)</td>
</tr>
<tr>
<td>Bridge</td>
<td>6.1 (0 to 34.9)</td>
</tr>
<tr>
<td>Clam</td>
<td>9.1 (0 to 157.6)</td>
</tr>
<tr>
<td>Crunch</td>
<td>19.9 (0 to 64.3)</td>
</tr>
<tr>
<td>Tucked squat</td>
<td>11.1 (0 to 76.3)</td>
</tr>
<tr>
<td>Untucked squat</td>
<td>11.7 (0 to 43.5)</td>
</tr>
<tr>
<td>Leg lift</td>
<td>52.7 (0 to 109.8)</td>
</tr>
<tr>
<td>Plank</td>
<td>14.0 (5.3 to 51.8)</td>
</tr>
<tr>
<td>Thigh adduction</td>
<td>11.9 (0 to 77.5)</td>
</tr>
</tbody>
</table>

Median changes in area and length are comparisons of each individual exercise to rest. Mean differences compare strength, area, and length changes between each exercise and Kegel. Positive differences represent higher squeeze pressure, wider area, and longer length than Kegel; negative values are lower squeeze pressure, narrower area, and shorter length versus Kegel. P value is related to the difference as compared with Kegel (paired Wilcoxon signed rank test).

*Median squeeze pressure of Kegel contraction = 24.3 (13.8–45.4) cm H₂O.
†Median Kegel LH area change = −0.13 cm² (−4.6 to 3.9).
‡Median Kegel PFM length change = −0.46 cm (−2.2 to 1.3).

CI indicates confidence interval.
were “the same” difficulty as Kegels to perform, but 47% (7/15) felt that the common exercises were “easier” or “much easier” to perform than Kegels. In response to the question, “In comparison to Kegel exercises, how well are you able to perform these exercises?” the median reply was “better,” with 60% (9/15) stating “better” or “much better.” Eighty percent (12/15) of participants stated they were “more likely” or “much more likely” to perform the 10 common exercises in comparison to Kegel exercises.

DISCUSSION

Numerous types of exercises have been shown to improve health but are hampered by issues of compliance and motivation; pelvic muscle exercise is no different. Without seeing immediate benefits, even motivated people can lose interest or get frustrated with what appears to be an ineffective exercise. Assuming that correctly done PFM exercises are indeed effective, correct regular usage should lower the burden of symptomatic pelvic floor disorders in postpartum women and even in the general population. The objectives of this study were to compare the effects of 10 common exercises to traditional Kegels on the LH area, PFM length, and PFM strength, with the goal to identify which exercises primarily or secondarily activate pelvic floor muscle and to what extent. We have identified 3 exercises (bird dog, plank, and leg lift) that should be evaluated as alternative or additive exercises to Kegel as they affect PFM strength and length and LH area similarly to Kegel. Several of the exercises activated the pelvic floor similar to Kegel in 1 aspect (either generated squeeze pressure, narrowed the LH area, or shortened the PFM). Bridge, clam, and plié exercises each clearly affected the PFM differently than Kegel in all measures.

Other investigators have quantified the constriction of the LH area during PFM contraction and alternative exercises such as transversus abdominis contraction.27,29,32 Thyer et al33 and Braekken et al30 both highlighted the reliability of ultrasound measurements of the PFM, and their findings are consistent with those in our study. In these studies, women presented to a urogynecology clinic and healthy parous volunteers had LH area at rest measured (18.9 [5.0] cm², 19.74 [16.81–22.67] cm², and 20.46 [17.49–23.42] cm²), and with PFM contraction, mean LH area was 15.4 (3.8) cm², 14.70 (12.82–16.58) cm², and 15.24 (12.78–17.69) cm². Our study was consistent with the LH area at rest (median, 16.1 [range, 13.0–20.6] cm²) and during contraction of 15.7 (3.4) cm². Bo et al38 examined the effects of transversus abdominis contractions as compared with PFM contractions on the LH area. When transversus abdominis contractions were performed, there was a significantly lower reduction in LH area, and in 2 cases, a widening of the hiatus was noted. This may be consistent with our findings, as several of the exercises that engaged core muscles (ie, bridge, crunch, plank) showed a significantly lower reduction of LH area than Kegel. However, leg lifts (which also engage the core) actually reduced the LH area similar to Kegel, so the interaction between core abdominal muscles and PFM may be more complex.

A limitation of this study is that the Peritron vaginal manometer does not distinguish Valsalva pressure from PFM squeeze pressure; although we were quite vigilant in examining the patient and adjusting incorrect form to exclude overt Valsalva, this is a limitation of the device. Few patients needed adjustments. A limitation of ultrasound is that it is challenging to obtain ideal images in each position, and thus some participants performed the exercise up to 4 times maximum. This was rare, and for each exercise, the median number of attempts necessary was 1.5. Although we cannot comment on the generalizability of these findings outside postpartum women, these are often women targeted by physicians or are themselves seeking PFM rehabilitation and are commonly managed conservatively. A strength of the study is the number of accepted, easy-to-perform exercises tested, and the quality, objective, reproducible data obtained with high interrater reliability. Another strength is that the fitness/activity level of the group was representative of a general population, and thus the results are generalizable (ie, 27% women did not exercise at all, 33% exercised occasionally or once per week, 33% exercised 2–3 times per week, and only 7% 4–5 times per week.)

All participants in this study had performed at least a few of these exercises in the past and in general rated these as easier to perform than Kegels. They also felt that they performed the common exercises better and were more likely to perform these than Kegels. Even busy postpartum women, given the proper education, could find a short period of time to do effective exercises, particularly if they see results in addition to pelvic floor strength such as relaxation, tone, overall body strength, weight loss, and flexibility. For future direction, given that multiple exercises seem to be effective, they could be bundled into a short routine and then studied clinically to determine their effect on symptoms of pelvic floor disorders.

REFERENCES


