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THE IMPACT OF A PELVIC FLOOR MUSCLE TRAINING PROGRAM ON URETHRAL SIZE, MOBILITY AND SUPPORT

<u>Hypothesis / aims of study</u>

When compared to continent women, women with stress urinary incontinence (SUI) have smaller urethral sphincter cross sectional area, increased urethral mobility, and defects in urethral support structures. Pelvic floor muscle (PFM) training is effective at alleviating symptoms of SUI in approximately 50% of women, but the mechanisms of action of such training remain largely unknown. The purpose of this study was to determine whether, in women with SUI, a 12 week program of PFM training altered urethral cross-sectional area, urethral mobility during cough or urethral support.

<u>Study design, materials and methods</u>

Twenty-two women with SUI volunteered to participate in a twelve-week program of PFM strengthening exercises. After screening to ensure that their primary complaint was SUI, that they had no evidence of overactive bladder or neurological conditions, and that they did not have significant prolapse (i.e. POP-Q <=stage 2), volunteers completed the Urogenital Distress Inventory (UDI) the Incontinence Impact Questionnaire (IIQ) and underwent an ultrasound imaging evaluation using a General Electric Voluson-i imaging system. The ultrasound investigation consisted of determining the following measures:

From volume images captured using a 3D endoprobe placed at the urethral meatus, the urethral cross sectional area was determined at steps of 2.5 mm (5mm and 2.5 mm distal to the mid-point between the inferoposterior aspect of the pubic symphysis and the bladder neck, at the midpoint between the inferoposterior aspect of the pubic symphysis and the bladder neck, and 2.5 and 5mm cranial to the midpoint between the inferoposterior aspect of the pubic symphysis and the bladder neck). At each location, a cross section of the urethra was taken perpendicular to the anterior urethral border and the cross sectional area of the urethral lumen and mucosa was subtracted from the overall cross sectional area.

From sagittal plane images captured at 36Hz using a 2D curvilinear probe placed on the perineum, bladder neck excursion during coughing was determined in the sagittal plane during maximal effort coughs performed in both supine and standing positions.

Using volume images from a 3D curvilinear probe placed on the perineum, the dimensions of the levator hiatus at rest were determined with the patient in supine.

In both supine and standing positions, from sagittal plane images using the 2D curvilinear probe located over the perineum, the resting position of the bladder neck was determined by measuring the perpendicular distance from the bladder neck to a line drawn between the distal aspect of the pubic symphysis and the anorectal angle. This measure was repeated at the end of a maximal effort Valsalva manoeuvre.

The participants then attended 12 weeks of weekly one-on-one physiotherapy sessions with a licensed physiotherapist with post-graduate training in pelvic floor assessment and treatment. The program involved education, strength, power and endurance training of the PFMs, and the prescription of a home exercise program in which the women were instructed to perform three different PFM exercises daily, with 3 sets of ten maximal effort PFM contractions performed during each exercise. All outcome measures (UDI and IIQ questionnaires and ultrasound imaging) were repeated after the 12 weeks of PFM training. Separate repeated-measures analyses of variance (α=0.05) were performed for each outcome measure.

<u>Results</u>

Data from fifteen participants were available for analysis (pre-test computer files were corrupted in 4 subjects, 3 subjects dropped out of the study). The participants had lower scores on the IIQ measured after compared to before the intervention (10.05±7.69 vs. 36.34±21.89 respectively; p_{adj}=0.010); the difference in the UDI score was lower but non-significant (29.01±17.74 after treatment vs. 44.15±21.49 before treatment; p_{adj}=0.356).

At all five measurement locations, the urethral wall was significantly thicker after as compared to before the 12 week training program. The largest increase was seen at the point 5mm cranial to the midpoint between the inferioposterior aspect of the pubic symphysis and the bladder neck, where the cross sectional area increased from 1.56±0.43 cm^2 to 1.87±0.43 cm^2.

The dimensions of the levator hiatus at rest (antero-posterior diameter 5.97±0.86cm; medio-lateral diameter 4.41±0.72 cm; area 9.79±2.31cm^2; circumference 22.94±2.96cm) did not change after treatment compared to before the 12 week training program.

There was significantly less bladder neck movement seen during coughing in standing after the 12 week PFM training protocol (0.96±0.66cm) as compared to before (1.84±1.05 cm) the protocol(p_{adj}=0.0078). The difference in bladder neck motion seen during coughing performed in supine between the initial test (1.17±0.65 cm) and after the PFM training protocol (0.88±0.64cm) was not significant(p_{adj}= 0.9967).

In both supine and standing, the bladder neck was more cranial relative to the levator plate before treatment (supine = 3.06± 0.48 cm, standing 1.73±1.03 cm) than it was after treatment (supine = 2.91±0.25 cm, standing = 1.22±0.93 cm; p_{adj}<0.005) and the displacement of the bladder neck at end-Valsalva was greater after treatment (supine = 2.12±0.93cm; standing = 1.81± 0.70 cm) compared to before treatment (supine = 2.01±1.08cm; standing = 1.22±0.93 cm; p_{adj}<0.005).

<u>Interpretation of results</u>

This study demonstrates the effect of PFM training on the structure and mechanics of the continence system is women with SUI. Since the urethral sphincter contracts in tandem with the levator ani, the increase in urethral cross sectional area may be associated with hypertrophy of the striated urethral sphincter muscle induced by PFM exercises. The reduced mobility of the bladder neck seen on coughing in standing is likely a result of improved strength or motor control of the levator ani group.

The PFM training did not result in any evidence of improvement in urethral support, as the levator hiatus dimensions did not change with treatment. The finding that the position of the bladder neck relative to the levator plate was more caudal after treatment might be an artefact. It is possible that with training, the position of the bladder neck within the pelvis did not change but the anorectal angle sat more cranially in the pelvis, creating the appearance that the bladder was sitting more caudal relative

to the levator plate. Given the lack of a bony landmark (coccyx/sacrum) to use as a reference point on imaging, it is not possible to determine whether or not this explanation holds true without repeating the study using magnetic resonance imaging.
Most curious was the finding that the displacement of the bladder neck at the end of the Valsalva manoeuvre was greater after treatment than it was before treatment. This might be explained by patients having learned how to perform a stronger Valsalva manoeuvre with training, by patients being more confident that they would not leak urine during this manoeuvre after undergoing PFM training, or by patients being less concerned about the embarrassment of urine leakage or passing gas during this manoeuvre on repeated examination.
The differences seen in continence mechanics between supine and standing might explain why leakage episodes are more common in the upright position.

Concluding message
A 12 week PFM strengthening program resulted in increased urethral cross sectional area and reduced urethral mobility in this cohort. This finding suggests that a larger randomized controlled trial will be useful to confirm these findings and to further determine the mechanisms through which PFM training affects continence function in women with SUI.

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Was this study approved by an ethics committee?	**Yes**
Specify Name of Ethics Committee	**Queen's University and Allied Hospitals Health Sciences Research Ethics Board, The Ottawa Hospital Research Ethics Board**
Was the Declaration of Helsinki followed?	**Yes**
Was informed consent obtained from the patients?	**Yes**