Research Report

The Role of the Obturator Internus Muscle in Pelvic Floor Function

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ABSTRACT

Objective: To investigate the effects of obturator internus (OI) strengthening on pelvic floor muscle (PFM) strength and hip external rotation (ER) strength.
Study Design: Randomized controlled trial.
Background: Rehabilitation strategies for pelvic floor disorders include PFM strengthening, but often this is not sufficient. Muscles surrounding the PFM (specifically, the OI due to a shared fascial attachment with the PFM) may play an important role in normal function and provide a target for rehabilitation that is more amenable to strengthening.
Methods and Measures: Forty nulliparous women 18 to 35 years old were randomly assigned to an exercise group (EX) or a control group (CON). The EX group completed an exercise program targeting strengthening of the OI muscle (hip ER). The EX group performed 3 sets of 10 repetitions of each exercise 3 times per week for 12 weeks. The CON group participated in testing sessions. ER strength (dynamometer peak force measure) and PFM strength based on Peritron (Laborie Medical, Ontario, Canada) peak vaginal squeeze pressure were measured. Separate repeated-measures analysis of variance was used with $\alpha = .05$ to compare ER strength and vaginal pressure for each group after 12 weeks. Results are mean ± SEM.
Results: The EX and CON groups were not different at initial assessment in age, ER strength, or PFM strength ($P > .05$). The EX group showed increased peak pressure (24.21 ± 3.72 vs 35.43 ± 3.13 cm H_2O; $P < .05$) and ER strength (16.44 ± 1.1 lb vs 19.95 ± 0.69 lb; $P < .05$). The CON group did not show change in peak pressure (32.16 ± 3.54 cm H_2O vs 27.37 ± 2.5 cm H_2O; $P > .05$) or ER strength (17.36 ± 0.54 lb vs 17.45 ± 0.65 lb; $P > .05$).
Conclusion: Strengthening of muscles surrounding PFM such as the OI could improve PFM strength (peak pressure) in nulliparous women, indicating that muscles other than the pelvic floor may be appropriate for rehabilitation.
Key Words: muscle, obturator internus, pelvic floor

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There are no conflicts of interest to declare.

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INTRODUCTION

Pelvic floor muscle dysfunction (PFMD) is the broad term used to describe a number of disorders in the realm of reproductive health. It includes urinary and fecal incontinence (UI and FI, respectively), pelvic organ prolapse, sensory and emptying abnormalities of the lower urinary tract, defecatory dysfunction, sexual dysfunction, and chronic pain syndromes.[1] Mechanisms underlying PFMD are not fully understood and are complicated by many variables such as age, sex, pregnancy, obesity, low back pain, and many other conditions and diseases. In addition, dysfunction can be the result of damage to multiple structures such as muscles, fascia, and nerves.[2]

To date, pelvic floor muscle (PFM) training is the primary method of nonsurgical intervention in PFMD, with Kegel exercises[3] being the primary means of strengthening the PFMs. There is strong evidence that PFM training is effective in treating UI (urge [UUI], stress [SUI], and mixed), but it is unclear whether other exercise programs have the potential to improve outcomes.[4] In cases wherein a woman is unable to activate the PFMs correctly, rehabilitation of other muscles may be necessary. There is evidence that muscles located outside the pelvis or muscles other than the levator ani, such as the abdominal muscles, can impact pelvic floor function,[5–7] and it is logical that biomechanical deviations from poor posture, hip dysfunction, or sacroiliac dysfunction may impact the PFMs.[8]

While the connective tissue, ligaments, and organs of the pelvis are important structures, the other muscles around the pelvis have the greatest opportunity to assist in pelvic floor function due to the fact that they can be consciously exercised to improve function. One primary muscle of interest is the obturator internus (OI) muscle, which originates at the ischiopubic ramus and obturator membrane of the pelvis and inserts on the medial aspect of the greater trochanter of the femur.[9] The OI acts to externally rotate the hip. Interestingly, this muscle actually shares a fascial attachment with the PFMs, giving it the potential to be an integral player in pelvic floor function and rehabilitation. It is currently unknown the effect of targeted exercise of OI on the function of the pelvic floor. Other investigators have theorized that hip muscles may impact the pelvic floor through this facial attachment, but the evidence has been limited by small sample sizes, and evidence based on changes in symptoms with no measure of muscle function.[10,11]

We have recently described the muscle architecture of the PFMs.[12] Muscle architecture is defined as the arrangement of muscle fibers relative to the axis of force generation and is the primary predictor of muscle function.[13] Muscle architecture governs the magnitude of force a muscle can generate, how fast it contracts (velocity), and its active range (excursion). On the basis of our recently published work,[12] we determined that the PFMs are actually quite thin—more so than we would have anticipated, based on clinical examination and based on their critical functions of supporting the abdominal contents and maintaining sphincter closure.[14] On the basis of a sensitivity analysis using the architectural parameters that we measured, the PFMs are able to produce enough force to counteract changes in intra-abdominal pressure during less rigorous activities of daily living (standing, performing an abdominal crunch).[12] However, for more severe events (coughing, jumping), intra-abdominal pressure clearly exceeds the maximum force generated by the PFMs in isolation.[12] Even if the muscles are forced to lengthen during a contraction (which can actually double force production),[15] the PFMs alone cannot withstand the increase in intra-adominal pressure that occurs in these more forceful activities. This implies that other parallel structures, such as the OI muscle, are required to assist the pelvic floor to maintain pelvic floor function, including maintaining continence.

A recent study by Jordre and Schweinle[10] compared resisted hip rotation and PFM training in women with SUI. Both groups improved on the basis of symptoms, but this study is limited by a lack of any measures of strength as a possible mechanism for symptom improvement.

Therefore, the purpose of this study was to investigate the effects of OI strengthening on the muscle strength (peak squeeze pressure) of the pelvic floor and on hip external rotation (ER) strength. We hypothesized the exercise group would have increased PFM strength compared with the control group after a 12-week hip strengthening intervention.

METHODS AND MEASURES

Subjects

This study was approved by the institutional review board at San Diego State University. Inclusion criteria for participation included women, 18 to 35 years old, who had never been pregnant (miscarriages counted as pregnancy), who had never given birth, and who were not currently being treated for a pelvic floor dysfunction and had no diagnosis of pelvic floor dysfunction. Inclusion criteria were purposefully quite broad to generalize to a larger population of women. Volunteers were recruited through mailing announcements from a population from San Diego State University Exercise and Nutritional Sciences students during the spring and fall semesters of 2014. Subjects were randomized into a control (N = 20) or exercise group (N = 20), and the lead investigator was blinded to these assignments.

Procedures

Informed consent was obtained from all participants prior to participation in this study. At the start of the first and the last examination, each participant was asked to complete the Pelvic Floor Distress Inventory (PFDI-20). The questionnaire gathers subjective information about the individual's bowel and bladder habits and ensured that the subjects met the aforementioned requirements for this study. A score of greater than 20 on any section of the PFDI-20 would have prompted referral to a provider. This was an arbitrary cutoff that we believed would limit participation of those with undiagnosed pelvic floor dysfunction. All participants scored less than 20 on each section of the PFDI-20 (see Table 1). Participants were also asked about current exercise routine and any pelvic floor exercises to confirm consistency in activity throughout.

The lead investigator conducted each examination throughout the study. Hip external rotator strength was measured using a MicroFET3 digital manual

Table 1. Demographics Information of Control and Exercise Group: Means (SD)[a]

	Control	Exercise
Age, y	20 (2)	21 (3)
PFDI-20 score	10 (12)	11 (8)
Body mass index, kg/m^2	21 (2)	23 (2)

Abbreviation: PFDI-20, Pelvic Floor Distress Inventory.
[a]There were no differences in group demographics. $P > .05$.

muscle dynamometer (Hoggan Scientific, Salt Lake City, Utah) placed against the lower leg (as described by Harris-Hayes et al[16]). This handheld instrument is a load cell–based strain gauge dynamometer through which a force distorts a strain gauge and converts it to an electrical signal and has good reliablity.[16] The participant was seated at the edge of the examination table with the hip in the neutral rotation position and the hip and knee flexed to 90°. The examiner placed the participant's leg at the end range of ER and asked the participant to hold the position and resist being moved out of the position. The examiner then applied force to the lower leg (just above the medial malleolus) in order to "break" the participant's holding position. This was repeated 3 times on each leg, with 30 seconds of rest between each trial. The peak force (pounds) of each trial was recorded and then averaged across all 3 trials for analysis.

The investigator visually assessed and confirmed each subject's ability to contract and relax the pelvic floor. As reported by Bø et al,[17] up to 30% of women may be unable to perform a correct PFM contraction, which could then lead to inaccurate reporting of vaginal pressure. All participants were able to contract the pelvic floor correctly based on visual confirmation of a lift in the tissues of the perineum. In addition, the investigator performed an internal manual assessment of the pelvic floor and confirmed pelvic floor contractions were performed correctly based on a sensation of squeezing and lifting around the examiner's finger. The investigator palpated the OI and checked for any pain by inserting a finger into the vagina and applying pressure slightly laterally and anteriorly while the participant externally rotated the hip against resistance.

The Peritron perineometer was used to measure PFM force production as previously described by Bø et al.[18] The Peritron device is reliable and valid.[19–21] This device is 10.8 cm in length and 2.8 cm in diameter and measures vaginal squeeze pressure through a conical sensor covered with a medical silicone rubber sheath. The sensor is connected to a handheld microprocessor with a latex tube, which allows measurement of squeeze pressure in centimeters of water (cm H_2O). The pressure sensor was placed in the vaginal canal and inserted to a standardized depth such that 1 cm of the Peritron sheath was visible as recommended in the Peritron handbook. The gauge was set to zero and then 3 trials were performed with the subject in a hook-lying position, with the hips and knees in neutral rotation, with the average of the 3 trials used for analysis. Subjects were instructed to squeeze with maximal force without use of any accessory muscles, and 30 seconds of rest were provided between trials. Only trials where the sensor moved inward were considered acceptable and used in the analysis. Peak pressure was recorded from the Peritron after each correct PFM contraction.

Confirmation of proper PFM contraction was additionally obtained using transabdominal ultrasound imaging (GE Ultrasound Voluson i/e BT11; GE Healthcare) to confirm movement of the full bladder superiorly (ie, base of the bladder deflected superiorly) with a PFM contraction. Ultrasound imaging was performed separately from the Peritron testing.

Exercise Protocol

Each participant was randomly assigned to either the exercise group or the control group after the initial assessment session. Participants of the control group were asked to maintain their normal level of fitness and avoid adding exercises or activities to their typical routine. Participants of the exercise group were asked to maintain their normal level of fitness and avoid adding exercises or activities to their typical routine, with the exception of the assigned exercises for this study. The assigned exercises included clamshell exercises, isometric wall ER, and "monster walks" (Table 2). These exercises were chosen on the basis of exercises that were commonly being assigned to patients in a clinical setting and were designed to be performed with little equipment needed. Each exercise subject was instructed by a research assistant how to properly perform the exercises. The exercises were performed in 3 sets of 10 repetitions 3 days per week for 12 weeks. Once per week, participants performed their exercises in the laboratory with a research assistant to confirm compliance and ensure proper execution. All participants in the exercise

Table 2. Description of the 3 Exercises Performed by the 20 Women in the Exercise Group[a]

Clamshell exercise	Lay on your side with hips and feet in line with each other, knees slightly bent. Raise your upper knee toward the ceiling. Repeat this 10 times. Rest. Goal is 3 sets of 10 repetitions. Repeat for other leg.
Isometric hip external rotation	Stand with your side against a wall. Lift your leg that is against the wall so that your hip and knee are at 90° angles. Press your thigh into the wall for 3-5 s. Do this 10 times. Rest. Goal is 3 sets of 10 repetitions. Repeat for other leg.
"Monster walk"	Tie the red TheraBand (Performance Health, Akron, Ohio) around your ankles. Start with your feet together. Step your right foot forward and out to just past hip distance. Bring the left foot to meet the right foot. Step left foot forward and out to just past hip distance apart. Bring right foot to meet left foot. Do 10 steps on each leg and repeat 3 times.

[a]All exercises were performed 3 times per week for 12 weeks.

group were given an exercise log to record which days the exercises were performed and a red TheraBand to use when performing monster walks.

Data Analysis

Data were analyzed using separate 2-way (group × muscle) repeated-measures analysis of variance, with an α value of .05 to compare ER strength and vaginal pressure for each group after 12 weeks. Results are presented as means ± SEM.

RESULTS

Forty women completed the 12-week protocol, 20 in the exercise group and 20 in the control group. Average age was 21 years in each group. The 20 women in the exercise group were all at least 80% compliant with meeting with a research assistant once per week to perform the exercises and based on the exercise logs, they were at least 80% compliant with exercising on their own. There was no difference between left and right ER peak forces ($P > .05$), so the bilateral average was used for analysis. Results of the 2-way analyses of variance indicate no baseline differences between hip ER peak force and PFM peak pressure between groups ($P > .05$). However, baseline to 12-week changes in muscle outcomes did differ between groups. Within-group differences were found for PFM peak pressure and ER peak force in the exercise group compared with the control group. At the end of the 12 weeks, the exercise group displayed an increase in PFM strength based on vaginal peak pressure measures (24.21 ± 3.72 cm H_2O vs 35.43 ± 3.13 cm H_2O; $P < .05$) and an increase in hip ER strength based on peak force (16.44 ± 1.1 lb vs 19.95 ± 0.69 lb; $P < .05$) (Figures 1 and 2). The control group did not statistically significantly show change in PFM peak pressure (32.16 ± 3.54 cm H_2O vs 27.37 ± 2.5 cm H_2O; $P > .05$) or hip ER peak force (17.36 ± 0.54 lb vs 17.45 ± 0.65 lb; $P > .05$) at 12 weeks (Figures 1 and 2). No subjects reported any pain with palpation of the OI muscle or any new onset of pelvic floor dysfunction based on the administered questionnaire for the duration of the 12 weeks.

COMMENT

To our knowledge, this is the first study that both measures vaginal pressure and provides initial evidence for the theory that strengthening the hip external rotator muscles does impact the strength of the PFMs. Our findings provide evidence that strengthening the deep rotators of the hip improved PFM strength based on vaginal peak pressure in a sample population of healthy, nulliparous women.

A recent study by Jordre and Schweinle[10] compared resisted hip rotation and PFM training in women with SUI. Both groups improved on the basis of symptoms, but this study did not provide any measures of strength as a possible mechanism for symptom improvement. Our study provides potential evidence for why symptoms might improve with resisted hip rotation. In the Jordre and Schweinle study, the intervention was 6 weeks long and different exercises were used in comparison with our study. More research is needed to determine the appropriate length of time and the best exercises to target these muscles and provide the best outcome in both strength measures and symptoms and to determine the exact mechanism for any changes in pelvic floor function (eg, overflow from OI to improve PFM activation). We used exercises that were commonly used in the clinic for hip strengthening; however, it is possible that there are other hip exercises that could have an even greater benefit. This was an initial exploratory study, so we chose exercises with a variety of positions and types of contractions that would easily fit into a daily routine. Further work is needed to determine the best possible exercises for use in the future.

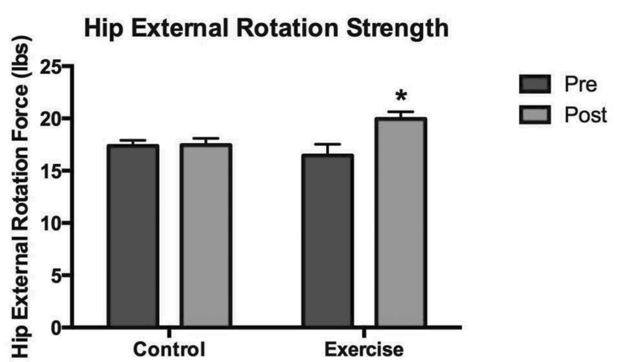

Figure 1. Hip external rotation strength at baseline (Pre) and at 12 weeks (Post) by group. [a]Statistically significant group difference from baseline. $P < .05$. There were no baseline differences between groups in hip external rotation peak force, $P > .05$.

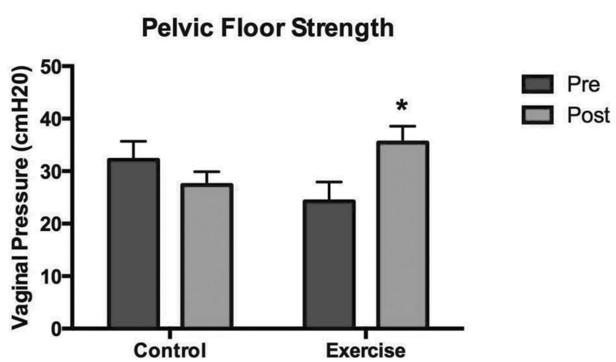

Figure 2. PFM strength at baseline (Pre) and at 12 weeks (Post) by group. [a]Statistically significant group difference from baseline. $P < .05$. There were no baseline differences between groups in PFM peak pressure, $P > .05$. PFM indicates pelvic floor muscle.

The increase in PFM peak pressure that we report is consistent with other reports in the literature. In a study using PFM training to treat SUI in young healthy athletes,[22] as well as a study in an older population,[23] the authors report a similar increase in vaginal squeeze pressure as what we report, indicating that our findings may have clinical significance. We are unable to compare our change in PFM peak pressure with other investigators who used a different perineometer,[18] but more research is needed to determine whether hip strengthening alone is equally as effective as PFM training or whether there may be an even greater benefit of combining both PFM training and hip strengthening.

Our study does have limitations to consider. Our study was limited by a small sample size of healthy, nulliparous women, so it is unknown whether these exercises would have a similar effect in a patient population. Motivation during the testing sessions could have been an issue, as the control group did not participate in any sham exercises and had less contact with the investigators. Because of the nature of the study, the exercises lacked progression and individuality, both elements of clinical exercise prescription. The OI muscle cannot be isolated from the rest of the hip external rotators, so the conclusion that the increase in PFM strength and hip ER strength was solely due to OI cannot be made on the basis of this study. These limitations all provide areas of future study.

Another limitation is that we did not have a formal way of assessing activity level between the groups and we cannot be sure that subjects did not add in pelvic floor exercises on their own. Adding activity monitors or utilization of a validated activity scale would have given us the ability to determine activity differences between the 2 groups or changes in activity level over time. We are only able to rely on self-report of our subjects that they maintained their regular fitness routines, but we are not able to quantify this information and compare between the 2 groups.

Despite these limitations, this study provides information that is important to clinical practice, as it provides evidence that muscles other than the pelvic floor may be appropriate for rehabilitation to improve pelvic floor function. While prior work has demonstrated improved symptoms with resisted hip rotation in women with SUI,[10] this study is the first to provide evidence that hip strengthening improved pelvic floor strength, suggesting a possible mechanism for symptom improvement. Future research should aim to determine whether this intervention has similar impacts on other populations of varied age, men, postpartum women, and individuals with pelvic floor dysfunction. Understanding and application of these data may lead to improved strategies for rehabilitation of patients suffering from pelvic floor dysfunction.

CONCLUSION

Strengthening the deep rotators of the hip surrounding the PFM, such as OI, improves PFM strength in healthy, young women. This could be particularly beneficial in patients who have difficulty performing the traditional Kegel exercises.

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