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Original Article

Effects of inner muscle resistance exercise on stress urinary incontinence: a randomized clinical controlled trial

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Abstract. [Purpose] This study investigated the effects of co-contraction resistance exercises of the transverse abdominal and pelvic floor muscles in middle-aged females with stress urinary incontinence. [Participants and Methods] We included 32 females with stress urinary incontinence and divided them into two groups: the inner muscle training group and the pelvic floor muscle group. The thickness of the transverse abdominal muscle was measured during four tasks: (1) rest, (2) maximum contraction of the transverse abdominal muscle, (3) maximum contraction of the pelvic floor muscle, and (4) maximum co-contraction of the transverse abdominal and pelvic floor muscles. In the latter three tasks, measurements were obtained while the participants performed resistance movements using a Thera-band®. A home program was conducted in both groups, and the intervention lasted for 8 weeks. [Results] The cure rates for SUI were 87.5% and 68.8% in the inner muscle training and pelvic floor muscle groups, respectively. After the intervention, the thickness of the transverse abdominal muscle significantly increased in the inner muscle training groups performing maximum co-contraction of the transverse abdominal and pelvic floor muscles and maximum contraction of the transverse abdominal muscle. [Conclusion] Inner muscle training exercises are more effective than pelvic floor muscle exercises in improving inner muscle function and urinary incontinence in middle-aged females.

Key words: Urinary incontinence, Transversus abdominis, Co-contraction resistance exercise

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INTRODUCTION

The overall prevalence of urinary incontinence during pregnancy is estimated to be around 58% and stress urinary incontinence (SUI) affects 31–42% of females (nulliparous and multiparous)[1]. Several studies have reported that the pelvic floor muscle (PFM; the inner unit) along with the transverse abdominal muscle (TAM), multifidus, and diaphragm maintain the stability of the trunk. The PFM exercise have been used in the management of SUI[2–4]. The PFM exercises are 50–69% effective in reducing episodes of urine loss in women[5–7]. The PFM exercises generally relax the abdominal muscle when the PFM contracts[8–10]. However, the principle of effective muscle training requires overload, and we believe that contracting only the PFM while relaxing the abdominal muscle may not have a sufficient effect as load strength. In our previous study, we found a significant relationship between the thickness of the TAM and the iEMG of the levator ani muscle[11]. The TAM

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and PFM co-contraction exercise intervention has been reported to increase the thickness of the TAM[12]. This result suggests that changes in the thickness of the TAM may be used to indicate changes in the electrical activity of the PFM.

Our hypothesis is that the intervention effect on SUI of both the TAM and PFM muscles co-contraction resistance exercise is better than the PFM only exercise. The purpose of this study was to investigate the effects co-contraction resistance exercises of the TAM and PFM on middle-aged females with SUI.

PARTICIPANTS AND METHODS

The required number of samples was calculated using G*Power software, the effect size was set to 0.5 and power (1-β=0.8), the required number of samples was fourteen for each group. We included 32 females who had experienced one or more episodes of SUI in the past one month[13]. They were randomly divided into two groups: the TAM and PFM co-contraction resistance group (inner muscle training [IMT] group; n=16) and the PFM group (n=16). All participants provided informed consent to participation in this study. This study was approved by the International University of Health and Welfare Ethics Review Committee (approval number: 20-Io-167).

All participants completed a questionnaire on UI, delivery history, delivery method and menstrual cycle. The thickness of the TAM was measured using ultrasound (SonoSite 180 PLUS, B mode,5-MHz linear transducer, USA). The thickness of the TAM was measured in all participants in the supine position under eight conditions at random. The reliability of the measurement method was verified from our previous research[10].

1) Resting state

2) Maximum contraction of the TAM: The participants were instructed to draw in the lower abdominal wall toward the spine (an action that specifically activates the TAM), and breathe in a relaxed manner without moving the lumbar spine.

3) Maximum contraction of the PFM: The participants were instructed to contract the muscles around the vagina “like a drawstring”, and lift them internally without tilting the pelvis posteriorly. There was no instruction regarding the use of the abdominal muscle.

4) Maximum co-contraction of the TAM and PFM: The participants were instructed to draw in the lower abdominal wall toward the spine, an action that specifically activates the TAM. When the TAM sustained isometric contraction, the participants were instructed to contract the muscles around the vagina “like a drawstring” to lift them internally and maintain the position for 5 seconds. During the above four tasks, measurements were taken while performing resistance movements using a Thera-band®. The resistance forces were measured by two hand-held dynamometers (ANIMA uTas MT1, HHD, Japan) held in both knees inside of the Thera-band® using the tester function of HHD. The resistance force was controlled at 1.5 kg.

Under each condition, the participants were asked to assume the supine position with their knees flexed at 90° and a pillow under their heads. To correctly perform the inner muscle contraction, a Biofeedback Stabilizer was used to provide visual feedback. The participants were asked to maintain the baseline at 40 mmHg. Except during the resting state, whenever the pressure of the Biofeedback Stabilizer decreased during the tasks, abdominal muscle re-education was provided by a physical therapist.

Ultrasound images of the anterolateral abdominal wall were obtained using a SonoSite ultrasound. The gel was interposed between the transducer and the skin. The transducer was positioned adjacent and perpendicular to the abdominal wall 25 mm anteromedial to the midpoint between the ribs and ilium on the midaxillary line and parallel to the muscle fibers of the transversus abdominis[12]. The same physical therapist took the measurements to avoid inter-rater errors. Ultrasound images were saved as still images. All thickness measurements were of muscle only, that is, between the fascia boundaries. To assess its effect, measurements were taken before and after the intervention. As a single-blind test, the measurer performed measurement and instruction, subject grouping was unknown. All measurements were performed by a licensed physical therapist.

A home program was conducted in the two groups. Participants in the IMT group performed TAM and PFM co-contraction training, with lateral resistance added to both knees using a Thera-band®, and 40 repetitions (two sets of 20 repetitions) of a 5-second co-contraction were prescribed. Females in the PFM group performed PFM training with 40 repetitions (two sets of 20 repetitions) of a 5-second contraction. They were instructed to perform one exercise session three times per week, and the intervention lasted for 8 weeks.

To determine whether there were differences in terms of participant characteristics between the exercise and control groups, an independent t-test was used. To determine the differences in the results of the questionnaire survey between the IMT and the PFM groups, the χ^2 test was used. Two-way repeated measures ANOVA was used to test for statistically significant differences, and the factors were intervention and group. Where a significant interaction was found, a paired t-test was used to compare the results before and after the intervention. Data were analyzed using SPSS Ver. 17.0 for Windows and the level of statistical significance was set at $p<0.05$.

RESULTS

There were no significant differences between the IMT and PFM group in terms of participant characteristics and measures before the intervention (Table 1).

The delivery history, delivery method, and menstrual cycle were not significantly different between the groups (Tables 2–4).

In terms of the frequency of UI, all participants had mild SUI at least once a week. Behavior during UI was 27% when coughing or sneezing, 20% when laughing out loud, 12% when lifting a heavy object, 12% when running, and 12% when exercising.

The cure rates of SUI were 87.5% (14/16) in the IMT group, and 68.8% (11/16) in the PFM group after 8 weeks of the intervention.

Table 5 shows the thickness of the TAM. The main effect was observed before and after 8 weeks of exercise ($p<0.05$). There were significant differences in the thickness of the TAM during maximum co-contraction of the TAM and PFM in active exercise in the IMT group ($p<0.01$). There were significant differences in the thickness of the TAM during maximum contraction of the TAM in resistance exercise using a Thera-band® in both the IMT ($p<0.05$) and the PFM ($p<0.01$) groups.

Table 1. Characteristics of the participants

	IMT group[a] (n=16)	PFM group[b] (n=16)	Sum total
Age (years)	50.9 ± 5.1	44.6 ± 10.2	47.8 ±8.5
Height (cm)	161.6 ± 4.4	160.3 ± 4.2	160.9 ± 4.3
Weight (kg)	63.9 ± 6.9	58.9 ± 3.6	61.4 ± 5.9

Values are presented as means ± standard deviation. There were no significant differences between groups at the 0.05 level.
[a]: IMT group: inner muscle training group.
[b]: PFM group: pelvic floor muscles exercise group.

Table 2. Delivery history

	IMT group[a] (n=16)	PFM group[b] (n=16)	Sum total
Primiparity	15	13	28
Para	1	3	4
Sum total	16	16	32

χ^2 test. There were no significant differences between groups at the 0.05 alpha level.
[a]: IMT group: inner muscle training group.
[b]: PFM group: pelvic floor muscles exercise group

Table 3. Delivery method

	IMT group[a] (n=16)	PFM group[b] (n=16)	Sum total
Natural childbirth	12	13	25
Cesarean section	4	3	7
Sum total	16	16	32

χ^2 test. There were no significant differences between groups at the 0.05 alpha level.
[a]: IMT group: inner muscle training group.
[b]: PFM group: pelvic floor muscles exercise group.

Table 4. Menstrual cycle

	IMT group[a] (n=16)	PFM group[b] (n=16)	Sum total
Steady	6	8	14
Irregular	3	3	6
Menopause	7	5	12
Sum total	16	16	32

χ^2 test. There were no significant differences between groups at the 0.05 alpha level.
[a]: IMT group: inner muscle training group.
[b]: PFM group: pelvic floor muscles exercise group.

Table 5. Comparison of TAM[a] thickness before and after intervention

		IMT group[b] (n=16)			PFM group[c] (n=16)		
		Before	After		Before	After	
TAM thickness (active exercise)	Resting state	2.7 ± 0.7	2.9 ± 0.9		2.3 ± 0.4	2.3 ± 0.4	
	Maximal contraction of TAM	4.1 ± 1.0	4.4 ± 0.7		3.9 ± 0.6	4.2 ± 0.9	
	Maximal contraction of PFM	3.3 ± 0.9	3.3 ± 0.9		2.8 ± 0.4	2.8 ± 0.8	
	Maximal co-contractio[d]	4.6 ± 0.9	5.1 ± 0.7	**	4.1 ± 0.7	4.4 ± 1.0	
TAM thickness (resistance exercise)	Resting state	2.8 ± 0.7	3.0 ± 0.9		2.4 ± 0.5	2.6 ± 0.4	
	Maximal contraction of TAM	4.1 ± 1.0	4.7 ± 0.7	*	3.6 ± 0.5	4.4 ± 0.7	**
	Maximal contraction of PFM	3.5 ± 0.9	3.4 ± 0.9		2.7 ± 0.3	2.8 ± 0.5	
	Maximal co-contraction[d]	4.6 ± 1.2	5.1 ± 0.9		4.0 ± 1.1	4.7 ± 0.9	

Values are presented as means ± standard deviation (unit: mm).
*p<0.05; **p<0.01 (before and after 8 weeks).
[a]: TAM: transverse abdominal muscle.
[b]: IMT group: inner muscle training group.
[c]: PFM group: pelvic floor muscle group.
[d]: Maximal co-contraction: maximal co-contraction of both the TAM and PFM.

DISCUSSION

We investigated the effects co-contraction resistance exercises of the TAM and PFM on middle-aged females with SUI. Participants in the IMT group and the PFM group showed not only an increased thickness of the TA but also improved SUI. The SUI cure rate in the IMT group was higher than that in the PFM group after intervention. In prior studies, PFM exercises had a cure rate of 50–69% for SUI treatment in females[14, 15]. Similar results were required in the PFM group.

In our previous study, the TAM output during simultaneous contraction and resistance movements was larger than that of the individual muscles[16]. The TAM was contracted by "belly-in" and the pelvis was in retroversion, raising the intra-abdominal pressure. The TAM contraction is a resistance exercise with raised intra-abdominal pressure, which increases PFM contraction. In addition, the six deep external rotators of the hip were contracted by resistance exercise using a Thera-band®. The internal obturator muscle was connected to the levator ani muscle at the pelvic obturator foramen. Based on the theory of muscle cooperative movement, a possible explanation is that internal obturator muscle contraction promotes levator ani muscle contraction.

Although the absolute amount of the TAM did not increase after eight weeks of intervention, there was an increase in the expansion rate of muscle contraction, an increase in activity of the TAM, and an improvement in the function of the inner muscle. In middle-aged females, IMT exercises are more effective than PFM exercises in improving inner muscle function and urinary incontinence.

The limitation is to consider how to control the resistance of the Thera-band®. Further investigations are required to increase the number of samples.

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Conflict of interest

The authors declare no conflict of interest.

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