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An Approach to Assessment of Female Urinary Incontinence Risk using the Thickness of the Transverse Abdominal Muscle during Co-contraction of both the Transverse Abdominal Muscle and the Pelvic Floor Muscle

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Abstract. [Purpose] This study examined physical factors associated with urinary incontinence (UI) in women. We hypothesized that, women with UI would show decreased thickness of the transverse abdominal muscle (TA) during maximal co-contraction of both TA and the pelvic floor muscle (PFM) compared with the women with no history of UI. [Subjects] The subjects were thirty-two women who subjects were divided into two groups: the UI group and the No-UI group. [Methods] We evaluated the thickness of TA by ultrasound, and hand-grip strength and the muscular strength of adduction in flexion of hip joint. The thickness of TA was measured during performance of 4 tasks: (1) at rest, (2) maximal contraction of TA, (3) maximal contraction of PFM, and (4) maximal co-contraction of both TA and PFM. [Results] The No-UI group had thicknesses of TA that were greater than those seen in the UI group in the tasks 3 and 4. In logistic regression analysis with UI as the dependent variable, the thickness of TA during maximal co-contraction was identified as an independent factor, and the cut-off value of the thickness of TA was 2.55 mm as determined by the Receiver-Operating-Characteristic (ROC) curve. [Conclusion] We found that the thickness of TA during maximal co-contraction of both TA and PFM is reliable and useful for the evaluating the risk of UI in women.
Key words: Urinary incontinence, Transverse abdominal muscle, Pelvic floor muscle

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INTRODUCTION

Urinary incontinence (UI) is well-known to profoundly affect women's QOL (quality of life). Three to five million people women are worried by UI beginning at the gravid period, the intrapartum period, the puerperal period, or the postmenopausal period.

Many cases of UI are stress urinary incontinence (SUI), and the success of pelvic floor muscle (PFM) exercise in the management of SUI has been confirmed by multiple randomized controlled studies. PFM exercise has been reported to be 50% to 69% effective at reducing urine loss episodes in women[1–4)]. In previous studies of female UI, we found that there are several ways of assessing severity of UI, such as bladder diary, pat test, and the urodynamic test. However, few studies have evaluated the risk of UI. Many UI cases are the result of PFM weakness, suggesting that risk of UI can be evaluated by PFM. Recently, several studies reported that PFM as an inner unit with the transverse abdominal muscle (TA), the multifidus muscle, and the diaphragm acts to maintain the stability of the trunk, and PFM has begun to be used as an approach to not only UI but also lumbar pain[5–7)]. In our previous study, a significant relationship was found between the thickness of TA and the iEMG of the levator ani muscle. This suggests that changes in thickness of TA may be used to indicate changes in the electrical activity of PFM.

In this paper, we examined factors of physical function associated with UI. The hypothesis was that, women with UI would show decreased the thickness of TA during maximal co-contraction of both TA and PFM compared with the women with no history of UI.

SUBJECTS AND METHODS

The subjects were thirty-two women who were divided into two groups: the UI group (n=7) and No-UI group (n=25) (Table 1). All subjects were primiparous women. All subjects gave their informed consent to participation in the study.

We evaluated the thickness of TA by ultrasound, and hand-grip strength and muscle strength of adduction in flexion of hip joint.

To measure the thickness of TA, four tasks were randomly performed in the supine position. To examine the measurement reliability, measurements during the four tasks were repeated.

1. Resting state.

2. Maximal contraction of TA. Subjects were instructed to draw in the lower abdominal wall toward the spine, action which specifically activates TA. The subjects were required to breathe in a relaxed manner. No movement of the lumbar spine was allowed.

3. Maximal contraction of PFM. Subjects were instructed to contract the muscles around the vagina "like a drawstring" and to lift them internally. No posterior tilt of the pelvis was allowed. There was no instruction to either use or not use the abdominal muscles.

4. Maximal co-contraction of both TA and PFM.

Subjects performed this task in the supine position with the knees flexed at 90°, and with a pillow under the head. Ultrasound images of the antero-lateral abdominal wall were obtained using an SonoSite (SonoSite 180 PLUS,B mode,5 MHz linear transducer). Gel was interposed between the transducer and the skin and the transducer was positioned adjacent to and perpendicular to the abdominal wall 25 mm antero-medial to the midpoint between the ribs and ilium on the mid-axillary line and parallel to the muscle fibres of the transversus abdominis[8]. The measurements and recordings were done by the same person, a midwife, 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 measure the muscular strength of adduction in flexion, subjects were asked to sit on a chair. A hand-held dynamometer (HDD, ANIMA MT-1) was fixed to the medial side of both knees, and the tester function of HDD was used to measure the maximal muscular strength of adduction in flexion. Subjects were instructed to tighten the adductor muscles for 3 seconds as an isometric contraction. The test was performed twice, and the maximum value was used for the analysis as the representative value.

Table 1. Subject Characteristics[a]

	No-UI (n= 25)	UI (n= 7)	Overall (n= 32)
Age (y)	45.8 ± 5.4	50.1 ± 4.2	46.8 ± 5.4
Height (cm)	161.3 ± 5.0	154.9 ± 7.5**	159.9 ± 6.2
Weight (kg)	59.0 ± 6.3	57.4 ± 11.1	58.7 ± 7.5

Note: values are mean ± standard deviation. **: p<0.01, [a]UI group: woman with urinary incontinence. No-UI group: woman with no history of urinary incontinence.

In order to determine the reliability of the measurement values of the thickness of TA, the interclass correlation coefficient (ICC) was calculated. To determine differences between the UI group and the No-UI group, the independent t-test was performed for each measure. To determine correlations between items, Pearson's correlation coefficient was used. Logistic regression analysis and the Receiver-Operating-Characteristic (ROC) curve were used to investigate the accrual of urinary incontinence and its relation to each factor. The Hosmer & Lemeshow test judged the adaptability of the logistic regression analysis. The data were analyzed using SPSS Ver. 12.0 for Windows.

RESULTS

Table 2 shows the values of the test-retest coefficients (ICC). The ICCs of the thickness of TA ranged from 0.88 to 0.96 for all tasks, showing high reproducibility (p<0.01).

The UI group had significantly decreased thicknesses of TA during maximal contraction of PFM (p<0.05) and maximal co-contraction of both TA and PFM (p<0.01) compared to the No-UI group. The hand-grip strength and the muscular strength of adduction in flexion showed no significant differences between the UI group and the No-UI group (Table 3).

Table 4 shows the correlations among the items.

Table 2. Measurements and ICC [a] (1, 1) of Thickness of TA [b] (mm) (n= 32)

	First measurement	Second measurement	ICC (1,1)
Resting state	2.3 ± 0.4	2.2 ± 0.4	0.95**
Maximal contraction of TA	2.4 ± 0.4	2.4 ± 0.4	0.87**
Maximal contraction of PFM [c]	2.4 ± 0.4	2.4 ± 0.5	0.93**
Maximal co-contraction [d]	2.5 ± 0.5	2.5 ± 0.5	0.92**

Note: values are mean ± standard deviation. *: p<0.05, **: p<0.01. [a] ICC: interclass correlation coefficient. [b] TA: transverse abdominal muscle. [c] PFM: pelvic floor muscle. [d] Maximal co-contraction: Maximal co-contraction both TA and PFM.

There was a high correlation among the thickness of TA during maximal contraction of TA, maximal contraction of PFM, and maximal co-contraction.

Logistic regression analysis with urinary incontinences as the dependent variable of the hand-grip strength, the muscular strength of adduction in flexion, and the thickness of TA during maximal co-contraction of both TA and PFM was performed by the stepwise method. Only the thickness of TA during maximal co-contraction of both TA and PFM showed a significant result ($p<0.05$) (Table 5). For urinary incontinence as a variable of state, the ROC curve of the thickness of TA during maximal co-contraction of both TA and PFM was plotted (Fig. 1). The area under the curve (AUC) was 81% and the cut-off value was 2.55 mm. The sensitivity was 100% and the specificity was 52% according to the cross-table of the cut-off value (Table 6).

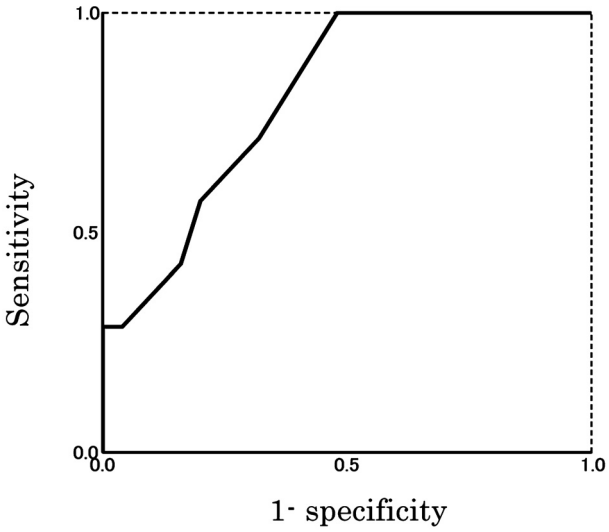

Fig. 1. The Receiver-Operating-Characteristic. (ROC) curve of the thickness of TA during maximal co-contraction of both TA and PFM. The area under the curve (AUC) was 81%, and the cut-off value was 2.55 mm; the sensitivity was 100% and the specificity was 52%. (Asymptotic significance probability =0.014)

DISCUSSION

The ICC of the thickness of TA was high, and showed high reproducibility. The purpose of this study was to examine physical factors associated with urinary incontinence in women. Supporting our hypothesis, the

Table 3. Results of physical tests performed by the UI group and the No-UI group

	No-UI group (n= 25)	UI group (n= 7)
Hand-grip strength (kg)	25.5 ± 6.2	26.9 ± 3.5
Muscular strength of adduction in flexion of hip joint (kg)	13.7 ± 4.6	14.6 ± 3.8
Thickness of TA [a] (mm)		
Resting state	2.4 ± 0.4	2.1 ± 0.3
Maximal contraction of TA	2.5 ± 0.4	2.2 ± 0.4
Maximal contraction of PFM [b]	2.5 ± 0.4	2.1 ± 0.3*
Maximal co-contraction [c]	2.7 ± 0.4	2.1 ± 0.3**

Mean ± SD, *p<0.05, **p<0.01. [a] TA: transverse abdominal muscle. [b] PFM: pelvic floor muscle. [c] Maximal co-contraction: Maximal co-contraction both TA and PFM.

Table 4. Pearson Correlation Coefficients between Measures (n= 32)

Hand-grip strength	–	0.35*	–0.13	–0.18	–0.11	0.10
Adduction in flexion [a]		–	0.13	0.18	0.10	0.13
Resting state			–	0.79**	0.76**	0.71**
Max. TA [b]				–	0.84**	0.82**
Max. PFM [c]					–	0.86**
Max. TA and PFM [d]						–

*: p<0.05, **: p<0.01. [a] Adduction in flexion: Muscular strength of adduction in flexion of hip joint. [b] Max. TA: Thickness of TA during maximal contraction of TA. [c] Max. PFM: Thickness of TA during maximal contraction of PFM. [d] Max. TA and PFM: Thickness of TA during maximal co-contraction both TA and PFM.

Table 5. Result of Logistic Regression Analysis with UI as the Dependent Variable

Item	Odds Ratio	95% CI [b]	p
Maximal co-contraction [a]	0.018	0.001–0.697	0.03
The Hosmer- Lemeshow Test	χ^2= 2.59	p= 0.96	

Note: Stepwise way. [a] Maximal co-contraction: Thickness of TA of maximal co-contraction

Table 6. The cross-table of the cut-off value of the thickness of TA during maximal co-contraction of both TA and PFM

	UI*group	No-UI group	Sum total
<2.55 mm	7	12	19
≥2.55 mm	0	13	13
Sum total	7	25	32

* UI: urinary incontinence. The sensitivity= 7/7= 1.00.
The specificity= 13/25= 0.52.
The positive predictive value= 7/19= 0.37.
The negative predictive value= 13/13= 1.00.

UI group had significantly decreased thicknesses of TA during maximal contraction of PFM and maximal co-contraction of both TA and PFM compared to the No-UI group. The hand-grip strength and the muscular strength of adduction in flexion showed no change between groups.

In logistic regression analysis, the thickness of TA of maximal co-contraction of both TA and PFM was identified as significant, indicating that the thickness of TA is useful for the evaluation of the risk of UI. In this research, the cut-off value of the thickness of TA during maximal co-contraction both TA and PFM was 2.55 mm according to the ROC curve, and the sensitivity was 100% and the specificity was 52%. The result shows that the detectability of the risk of urinary incontinence was high, and quantitative assessment of the risk of UI is possible with measurement of the thickness of TA during maximal co-contraction of both TA and PFM. In addition, the negative predictive value was 100 percent and the predictive accuracy was 74 percent, greatly exceeding the percentage of women with UI, 21.9 percent. This demonstrates that a high-precision UI forecast is possible using this model. In conclusion, the thickness of TA during maximal co-contraction of both TA and PFM is useful for the evaluation of the risk of female urinary incontinence.

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