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Assessment of pelvic floor muscle contraction in stress urinary incontinent women: comparison between transabdominal ultrasound and perineometry

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Abstract

Introduction and hypothesis Transabdominal (TA) ultrasound and perineometry have been currently used to assess lifting aspect and squeezing action of pelvic floor muscles (PFM) function, respectively, in women with stress urinary incontinence (SUI). However, no study has directly compared these measurements. The purpose of this study was to investigate the reliability and correlation between perineometry and TA ultrasound as measurements of different aspect of PFM function.
Methods A total of 28 women with SUI participated in the study. Vaginal squeeze pressure using a perineometer and bladder base movement on TA ultrasound was measured. Scattergram was depicted to determine the correlation between variables. Intraclass correlation coefficient and Bland–Altman plot were used to assess reliability.

Results Scatter diagram depicted significant correlation of TA ultrasound with vaginal squeeze pressure ($r=0.72$, $R^2=0.52$, $p<0.0001$). High reliability was found for measurements.
Conclusion TA ultrasound measurement may be an alternative measurement to perineometry when assessing PFM function.

Keywords Pelvic floor muscles · Perineometry · Transabdominal ultrasound · Stress urinary incontinence · Vaginal squeeze pressure · Reliability

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Introduction

The pelvic floor muscles (PFM) form the base of the abdominopelvic cavity and support the abdominopelvic organs [1]. PFM is thought to play a crucial role in generating and maintaining intra-abdominal pressure and in keeping urinary continence (UI) [2]. There is a positive link between the increase in PFM function and improvement in stress urinary incontinence (SUI) [3–5]. The theory behind PFM treatment of SUI is that strong contraction clamps the urethra, which, in turn, increases urethral pressure during an increase in intra-abdominal pressure [2]. Hence, the ability to reliably evaluate the contraction of these muscles is critical to document changes in PFM function throughout intervention in analyzing whether the training protocol has been effective or not.

Several subjective and objective techniques have been suggested to evaluate various aspects of PFM function for women with SUI attending physiotherapy. However, there is no general agreement on the best clinical assessment method. Perineometry is one of the most common measurement techniques currently used by physiotherapists (PT) to evaluate PFM contraction in clinical and scientific settings [1, 3, 6–9].

A perineometer is a simple, reliable, and minimally invasive instrument to obtain an objective measure of PFM strength by measuring vaginal squeezing pressure [9–11]. Several studies have demonstrated a good association between digital assessment and vaginal perineometry for assessment of PFM contraction in continent and incontinent women [6–9, 11, 12]. However, measurement of vaginal squeezing pressure by the perineometer may not be appropriate for use in certain populations for whom internal examination and using vaginal probe may be unacceptable [13, 14]. Real-time ultrasound has been lately applied by PT to assess lifting of the pelvic floor. It gives direct visualization and feedback about PFM contraction and exercise performance. Transabdominal (TA) ultrasound has been applied as a reliable method to measure the movement of the bladder base as an indicator of PFM activity during muscle contraction [1, 13–17]. It is completely noninvasive, patient-friendly, quick and easy to apply and appropriate in specific populations where vaginal assessment might not be favorable (children, adolescents, victims of sexual abuse). Previous studies have shown a significant correlation between TA ultrasound and digital palpation [13, 15], between TA and transperineal ultrasound [13, 14, 18], between transperineal ultrasound and digital examination [13, 14, 19, 20], between digital examination and perineometry [6–9, 11, 12], or between transperineal ultrasound and perineometry [19, 21] for assessment of pelvic floor contraction. To our knowledge, no study has directly compared TA ultrasound measurement with vaginal perineometry as two simple clinical methods that evaluate different aspects of PFM activity in symptomatic women. The purpose of this study was to investigate the correlation between perineometry and TA ultrasound measurement for assessment of PFM contraction and to evaluate the reliability of the measurements in women with SUI.

Materials and methods

Subjects

A descriptive correlational design was utilized to investigate the relationship between vaginal perineometry and TA ultrasound measurement for assessment of PFM contraction in women with SUI. A total of 28 women aged 25 to 55 years (mean age=41.19 years, SD=8.16) presenting with symptom of SUI were selected for inclusion in the study. The subjects had been claimed by an urogynecologist as having symptoms of SUI. Inclusion criteria were willingness to participate, ability to contract the PFM evaluated by vaginal palpation, and having had urine leakage on coughing, sneezing, laughing, lifting, and any activity that increases the intra-abdominal pressure [21]. The type of UI had been assessed using a urinary symptoms questionnaire [22]. Exclusion criteria were pregnancy, known neurological disease, low back pain, pelvic surgery, history of pelvic fracture, known respiratory disease, inability to contract PFM, urinary tract infection, and menstruation at the time of assessment. To avoid any confounding effect of training, subjects were excluded if they had PFM training at physiotherapy within the last 2 years. All the participants signed an informed consent form approved by the human subject ethic committee at the University of Social Welfare and Rehabilitation Sciences before participating in the study. Physical characteristics of the subjects can be seen in Table 1.

Transabdominal ultrasound measurement

A diagnostic ultrasound imaging unit set in B mode (Ultrasonix-ES500, Canada) with a 3.5-MHz curved array transducer was used for TA ultrasound measurement. We measured the amount of bladder base movement on ultrasound as indicator of PFM contraction based on the method explained by others [13–18]. For visualization of the bladder base, a standardized bladder filling protocol was used prior to imaging. The participants were tested in a crook-lying supine position with one pillow underneath the head. The hips and knees were flexed to 60°, and the lumbar spine was positioned in neutral. Ultrasound transducer was placed in the transverse plane immediately suprapubically angled in a caudal/posterior direction to obtain a clear image of the inferior–posterior aspect of the bladder. The marker was first placed on the bladder base at the rest. The participants were required to perform maximal

Table 1 Demographic data for 28 women with stress urinary incontinence

Variables	Mean ±SD	Lowest value	Highest value
Age (years)	41.19±8.16	25	55
Weight (kg)	66.90±11.10	45	84
Height (cm)	157.12±6.10	145	169
BMI (kg/m^2)	27.43±4.03	19.22	37.33
TA ultrasound measurement (mm)[a]	3.76±3.10	0.46	12.46
Vaginal squeeze pressure (cmH$_2$O)	19.27±12.03	2.56	47.46
Parity[b]	3 (5)	0	5

BMI body mass index, TA transabdominal

[a] The measurement is the amount of lift in millimeters

[b] Parity: data are median (interquartile)

contraction and were instructed to "draw in and lift the PFM" and to keep the contraction while breathing normally. When the contraction was visualized on the ultrasound screen, the image was fixed, and the subjects relaxed. It took less than 3 s. The marker was then located on the bladder base at the point of maximal displacement during muscle contraction, and the amount of bladder base displacement from resting position at the end of each contraction was measured in millimeter (mm). The ultrasound transducer was not displaced during the testing procedure, and the subjects were not able to see the ultrasound screen so that a biofeedback training effect was avoided. Only contractions with cephalic movement of the bladder base were measured as correct. Subjects performed three maximal contractions with no movement of the pelvis or low back region and without palpable contraction of hip adductor, rectus abdominal, or gluteal muscles. All contractions were held for 3 s with a rest of 10 s between each contraction. The mean value of three contractions was taken for the analysis. The reliability of TA ultrasound measurement for PFM contraction (ICC: 0.93, standard error of measurement: 0.13) has been previously reported [13].

Perineometry

Vaginal squeeze pressure was measured using the Peritron 9300V perineometer (Cardio Design, Victoria, Australia) that is a conical vaginal insert 28-mm in diameter and 108-mm in length. Covered in a thin, medical-grade silicon rubber sheath, the vaginal insert is connected to a microprocessor allowing for transmission of pressure reading in centimeters of water (cmH_2O) when the insert is compressed by external pressure. The reliability and validity of using a perineometer for measuring muscle strength has previously been established [7, 9, 11, 23].

After voiding, vaginal squeeze pressure was assessed by the same examiner using perineometry. The vaginal pressure probe was placed inside the vagina to a location where 0.5–1 cm of the insert was visible outside. The pressure sensor was set to 0 at the beginning of each contraction. The subject's position and the instructions to perform PFM contraction were the same as the ones used during ultrasound measurement. Only contractions with simultaneous observation of

inward movement of the perineum were registered as correct contraction [23, 24]. No biofeedback was given during the measurements. The participants performed three maximal contractions, and the mean value of three contractions was measured for the analysis. All testing procedure was performed by a PT in the biomechanics laboratory of the physical therapy department in the University of Social Welfare and Rehabilitation Sciences.

Reliability assessment

Twenty female volunteers (ten continent and ten incontinent) were assessed two times for intratester reliability of the TA ultrasound and perineometry measurements in a pilot study (Table 2). For this purpose, the examiner, at first, performed measurements in subjects, and then, after 30 min repeated the measurements in a blinded fashion and random order with the same procedure. The subjects and the order of measurements were randomly selected, different from the first examination sequence, to reduce the memory effect. The participants in the pilot study for reliability assessment were different from those who participated in main study.

Data analysis

Kolmogrov–Smirnov test was utilized to assess the normality of distribution for tested variables. Normal distribution was observed for variables. The intraclass correlation coefficient (ICC), two way mixed effect model, was used to assess intratester reliability of the measurements. The 95% limits of agreements method of reliability assessment with a confidence level of 95% was calculated using a Bland–Altman plot to assess absolute reliability. Scattergram with regression line was depicted to determine the correlation between TA ultrasound and perineometry measurements for PFM contraction. The significance level of 0.05 was chosen.

Results

Descriptive statistics for the subjects and measurement scores are presented in Table 1. The ICC values were 0.92

Table 2 The (mean ±SD) scores for the first and second measurements of TA ultrasound and perineometry in pilot study ($n=20$)

| Variables	First assessment	Second assessment
TA ultrasound measurement of bladder base lift (mm)	3.68±3.45	4.02±3.19
Vaginal squeeze pressure (cmH_2O)	14.07±8.58	17.53±13.06

TA transabdominal

and 0.87 for TA ultrasound and vaginal squeeze pressure, respectively. It indicates high intratester reliability for the measurements. The Bland–Altman plot of agreement in TA ultrasound measurement between test and retest is shown in Fig. 1. The Bland–Altman plot demonstrated that 95% of the observations fall between the limits of agreement for test and retest for both methods.

Figure 2 depicts the scatter diagram for the correlation between TA ultrasound and vaginal squeeze pressure measurements. A significant relationship was found between the measurements taken using TA ultrasound and perineometer for PFM contraction ($r=0.72$, $R^2=0.52$, $p<0.0001$).

Discussion

The results of this study showed that there is high correlation between vaginal squeeze pressure and TA ultrasound as two methods of measurement that assess two different aspects of PFM function (lifting aspect and squeezing action) in women with SUI. High intrarater reliability was found for both measurements.

The results derived from this study demonstrate high reliability for perineometry in assessment of PFM strength. Similar findings have been reported by others [7, 9, 11]. Previous studies have shown significant correlation between perineometry and digital palpation as the gold standard. However, a common validity problem in mea-
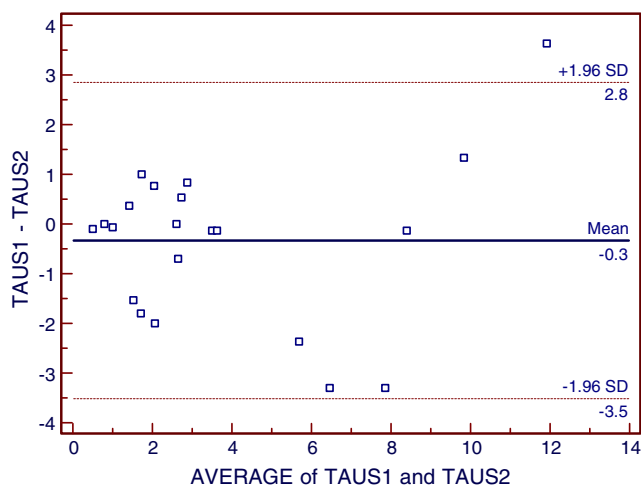
TAUS= Transabdominal Ultrasound

Fig. 2 Scattergram depicting correlation of TA ultrasound with perineometry. *TAUS* transabdominal ultrasound

surement of vaginal pressure is that any rise in abdominal pressure, such as valsalva maneuver, will increase the pressure measured in the urethra, vagina, and rectum. Because straining is common in women trying to contract their PFM, a wrong measurement can be recorded. It has been shown, however, that this can largely be avoided by use of clinical observation and proper teaching [23]. In this study, only contractions with simultaneous inward movement of the perineum were registered as correct contractions [23, 24]. However, this method may be inappropriate for use in certain populations in whom an internal examination may be unacceptable [13, 14].

More recently, TA ultrasound has been recommended to assess the "lifting" aspect of the pelvic floor by observing movement of the bladder base during PFM exercises. The amount of bladder base displacement on ultrasound is considered as an indicator of PFM function [1, 13–17]. This technique is comfortable for the patient, and the patient does not even need to get undressed, and the probe is not placed at the perineum. This makes it a suitable method in specific populations where internal examination may not be desirable, e.g., children [25], adolescents, victims of sexual abuse, and some ethnic groups. The reliability of this approach has been established previously [1, 13–17].

To our knowledge, this is the first study to directly compare these two methods, although TA ultrasound has been compared with digital assessment [13], and perineometry correlates well with transperineal ultrasound [19, 20, 26].

Considering the significant relationship between transperineal and TA ultrasound reported in the literature [13, 14, 18], our finding is in accordance with other studies showing a significant correlation between transperineal ultrasound measurement and perineometry [19, 20, 26].

The mean of the test (TAUS1) and retest (TAUS2) scores is plotted on the X axis and the differences between two scores on the Y axis. The horizontal interrupted lines represent the limits of agreement
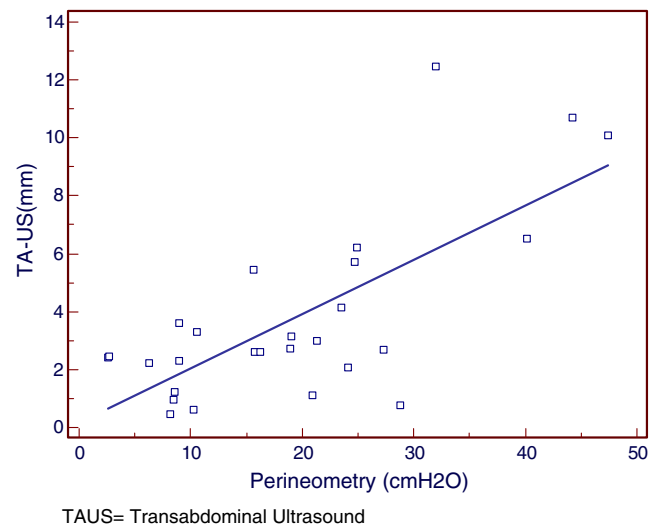
TAUS= Transabdominal Ultrasound

Fig. 1 The Bland–Altman plot for TA ultrasound measurements of bladder base lift. The mean of the test (TAUS1) and retest (TAUS2) scores is plotted on the *X axis*, and the differences between two scores on the *Y axis*. The *horizontal interrupted lines* represent the limits of agreement. *TAUS* transabdominal ultrasound

However, the lower correlation reported in previous studies between transperineal ultrasound parameters and perineometry may be due to the difference in the selection of the subjects and difference in the methodology. In this study, only contractions with cephalic movement of the bladder base were considered measured as correct, and the subjects who depressed bladder base during PFM contraction were excluded.

However, we acknowledge several important limitations. TA ultrasound measurements are made without reference to a bony landmark, and measurement of the bladder base elevation are only expressed relative to a movable starting point that makes it probably less repeatable than transperineal ultrasound [18]. Although our study showed the correlation of the strength of muscle contraction and the ability to perform an elevating contraction, it appears that they assess two different aspects of a PFM contraction. It means that strong muscles may not be able to lift high or, conversely, a weak and hanging pelvic floor may be lifted a long way.

In addition, our exclusion criteria may have been too rigid. We excluded the subjects with urge or mixed UI in order to assess the correlation in more homogenous population of incontinence.

Another area of concern in our study is the order of testing. The order of tests was not randomized and most of the patients were assessed by transabdominal ultrasound firstly and then, after voiding, were assessed by perineometry. However, we allowed adequate interval to minimize the effect of fatigue.

We suggest that this study could be done on the subjects with different type of UI in a randomized test ordering to provide more insight regarding the correlation between the measurements.

All of the measurements for TA ultrasound and perineometry were done by the same qualified PT, and the subjects were not allowed to know about their scores prior to end of testing procedures.

Conclusion

This study assessed the relationship between perineometry and TA ultrasound measurement for the assessment of PFM contraction and the reliability of the measurements. Our data indicate a highly significant correlation between TA ultrasound and perineometric scoring of PFM contraction. In addition, the results of this study showed high reliability for two methods used in this study. This comparative study suggests that TA ultrasound measurement of PFM contraction may be an alternative measurement to perineometry when assessing pelvic floor function especially in women in whom a noninvasive diagnostic method is preferred.

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