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# Reliability of Pelvic Floor Muscle Strength Measurement in Elderly Incontinent Women

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Pelvic floor muscles (PFM) play an important role in maintaining urinary continence with increasing age. Therefore, their contractile properties need to be evaluated. The aim of the study was to examine the reliability and correlation of simple techniques to measure PFM strength in elderly women with urinary incontinence. An interview was used to evaluate the ability to stop the urinary stream during micturition and to calculate the incontinence index. A pad test was applied to objectively evaluate the severity of the disease. Functional testing included a digital examination to measure the force and duration of one contraction, a perineometer measurement (Peritron) to assess maximal contraction force and contraction force of 5 s, and a cone-retention test (Femcon) while walking for 1 min and during Valsalva's manoeuvre. This procedure was performed on three separate occasions within one week. The 37 participating women with a mean age of $62 \pm 8$ (mean $\pm$ SD) years had a severity index of $4.4 \pm 2.6$ and a urine loss of $9.5 \pm 13.6$ mg during the pad test. Sixteen women were able to completely stop the urinary stream during micturition. The digital examination showed no intratester variability. The perineometer measurement showed that the absolute difference in maximal contraction force and mean contraction force within 5 s was less than 5.3 mm Hg and 4.5 mm Hg, respectively, with a probability of 0.95. While walking and during Valsalva's manoeuvre, 19 and 20 women, respectively, held the same cone in place on all three occasions. The maximal contraction force and mean force during the 5-s contraction correlated well with the ability to stop the urinary stream and the digital examination but only weakly with the cone-retention tests. The reliability of PFM strength measurement is highest in the digital examination, followed by perineometer measurements, and then by vaginal cone tests. As PFM function is easy to assess, it should be routinely done in the assessment of urinary incontinence in elderly women. *Neurourol. Urodynam. 21:42–47, 2002.* © 2002 Wiley-Liss, Inc.

**Key words: urinary incontinence; pad test; digital examination; perineometer measurement; vaginal cone test**

## INTRODUCTION

Urinary disorders in women are common and their prevalence increases with age [Brown et al., 1996]. In population-based studies, urinary incontinence was estimated to occur in 17–40% of community-dwelling women over 60 years of age [Diokno et al., 1986, Molander et al., 1990; Wetle et al., 1995].

The examination of an incontinent person generally includes an interview, an objective evaluation of the severity of disease, and functional testing, the latter consisting of digital as well as apparatus-based tests. Valid clinical parameters are required to assess pelvic floor muscle (PFM) strength.

Digital evaluation is an essential part of the PFM assessment. The original digital test described by Brink [Brink et al., 1994] measures pressure, displacement, and duration of a squeeze of the perivaginal muscles around the examiner's finger.

Perineometers [Bo et al., 1990b] and weight cones [Laycock, 1987] are the most commonly used instruments for assessing PFM status. The technical validity of the perineometer used in this study (Peritron 9300) has been described by the manufacturer: 95% of the readings are supposed to be correct to $\pm 1$ cm of water. Deformation of the sheath of the Peritron probe requires between 3 and 6 cm of water pressure. Thus, the reading on Peritron is always a little less than the actual pressure generated by the patient. As this is constant, it has no clinical relevance. Probe-to-probe deformation pressure varies from the mean by 0.4–0.6 cm of water. Clinical

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Abbreviations: EMG, electromyogram; ICS, International Continence Society; PFM, pelvic floor muscle.

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studies with this pressure measuring system have not yet been published.

Cones of equal shape and volume are available in sets of five but their weight gradually increases from cone to cone in the range of 20–68 g (12-g increments). A cone of appropriate weight inserted into the vagina tends to slip out. The feeling of losing the cone provides a powerful sensory biofeedback, which makes the PFM contract around the cone to retain it. Resting muscle strength is assessed as the heaviest cone retained in the vagina for one minute while walking. Active PFM strength is determined by the weight of the heaviest cone the patient can retain by contracting the PFM.

The reliability of tools used to investigate PFM strength in elderly women has not been rigorously examined so far. Therefore, the present study examined the test–retest reliability of PFM contraction measurements and correlations between the different tests in postmenopausal women suffering from urinary incontinence.

## MATERIALS AND METHODS

### Subjects

Women whose urinary incontinence was not of neurological origin were included in this cross-sectional investigation. Incontinence of neurological origin was excluded by urodynamic assessment. A further inclusion criterion was the absence of metabolic disease. Genuine stress or sensory urge incontinence was diagnosed according to the International Continence Society definition [Bates et al., 1976]. We defined a third group of patients suffering from urinary stress incontinence combined with urge symptoms but with no urodynamically proven detrusor contractions. Women who did regular exercise to train the PFM or received physical therapy such as low-frequency current to stimulate the pubococcygeus muscle were excluded. The study was explained to interested women and all participants signed a consent form. The study was conducted at the department of physical medicine and rehabilitation, University of Vienna.

### History

The topics covered in the interview included personal and medical history, especially gynaecological and urinary operations, and drug use. The women were also asked about their ability to stop the urinary stream after a 5-s period of micturition, which reflects the interplay of the external urethral sphincter and the levator ani muscles [Boucier et al., 1999]. The inability to deflect the urinary stream was graded as 1, the ability to deflect the urinary stream as 2, and the ability to completely stop urinary flow as 3. Information about the frequency and intensity of urinary leakage was used to calculate the incontinence index according to Sandvik et al. [1993], which consists of a rating scale from 1 to 8. One stands for the lowest and 8 for the highest degree of urinary incontinence. The height and weight of the women were also registered.

### Pad Test

An objective evaluation of urinary incontinence is important. A gold standard to assess the degree of urinary leakage is the pad test [Abrams et al., 1988; Siltberg et al., 1997]. It is a one-hour stress test performed with a standardised bladder volume. The pad weight difference was recorded in millilitres on a scale calibrated to 0.01 g.

### Functional Testing

Functional testing consisted of a digital examination and apparatus-based measurements including an examination with a perineometer as well as cone retention tests. This procedure was repeated three times within one week. Two investigators did the tests but each subject was examined by the same investigator on all three occasions.

Each subject was positioned in semisupine position with the hip flexed at about 45° and the knee flexed at about 120°. The legs were abducted and the soles of the feet in contact with each other to avoid adductor muscle contraction—one of the most commonly and erroneously measured muscles instead of PFM—during the measurement. The investigators ensured that the position was comfortable and that the adductor, gluteal, and abdominal muscles were relaxed.

The digital examination [Brink et al., 1994] ensured that the subject was capable of correctly contracting the perivaginal muscles. The women were instructed to "pull the PFM in and up as strongly as possible". In contrast to Brink, the duration was prolonged to 10 s to better assess the slow-twitch fibres, as the external urethral sphincter is solely, and the levator ani muscle mainly, composed of this type of fibre [Gossling et al., 1981]. The examiner's index finger was positioned in the vagina, registering pressure towards the finger and movement in cranial direction during correct contraction. Contraction was graded on a five-point scale as follows: 0 = no contraction, 1 = less than 2 s, 2 = 2–5 s, 3 = 6–9 s, and 4 = 10 s or more. Only the duration of a correct muscle-contraction technique was counted; a pushing movement was recorded as zero. If a woman did not correctly perform the PFM contraction she was repeatedly instructed until a correct contraction technique was achieved or until at least no abdominal or gluteal muscle contraction was identified by the examiner.

PFM contractions were measured quantitatively with a perineometer (Peritron 9300, Cardio Design pty ltd). The device consists of a compressible silicone rubber sheath over a skeleton that allows the central section to be pressed in radially in response to muscular contraction. It is 8 cm long and 3 cm in diameter, and is connected by plastic tubing to a manometer. A clean latex sleeve was fitted around the compressible silicone rubber sheath for each patient. The perineometer was then inserted into the vagina until one

centimeter of the sheath remained outside. After restoring the zero point the women performed a maximal contraction. They were instructed to "pull the PFM in and up as strongly as possible and to hold the position for 5 seconds". If an inward movement of the gauge was observed the maximum contraction force and the average of the 5 s of contraction were recorded. Three consecutive trials were performed with an interval of 30 s between every two. After each trial the calibrated zero point was restored. In the event of a pushing movement the measurement was counted as zero.

Additionally, cones (Femcon) were used to assess PFM strength. The patients were asked to place the lightest of the five cones into their vagina. The weight of the cone was increased until it could not be retained for one minute of brisk walking. In a further series, Valsalva's manoeuvre was performed, again starting with the lightest weight.

During the period of repetitive measurements (within one week) the patients received no instruction for pelvic floor exercise.

### Data Analysis

Descriptive analysis was performed on all variables. The reliability of the Peritron measurements (continuous scale) was analyzed by calculating the absolute pairwise differences between the three repeated measurements. The 95% quantile of the pooled differences was used to quantify reliability [Bland and Altman, 1986]. Therefore, 95% of the differences between the observed repeated measurements within a patient can be expected to be smaller than this limit. Additionally, the intraclass correlation coefficient was calculated to describe the degree of reliability. The reliability of the digital test and the vaginal cone tests (ordinal scale) was analyzed by calculating the maximum pairwise difference between the three repeated measurements. The percentage of patients rated equally by all three measurements was used to describe reliability of these measuring instruments and the intraclass correlation coefficient was calculated.

To describe the different instruments and to evaluate the correlations between the different instruments the median values of the repeated measurements were used. *P*-values less than 0.05 were considered statistically significant.

The SAS software Inc. (Cary, NC, 1996) was used for analysis.

## RESULTS

### Characteristics

Characteristics of the 37 postmenopausal women participating in this study are shown in Table I. Twenty-eight participants were parous and had delivered vaginally. Sixteen women were able to completely stop the urinary stream during micturition. During the pad test the women lost between 0.2 and 51.8 mg of urine. In daily life they used 1 [0; 2] pad per day.

**TABLE I. Characteristics**

| | |
|---|---|
| Age (years) | $62 \pm 8$[a] |
| Menopausal age (years) | $50 \pm 5$[a] |
| Height (cm) | $165 \pm 7$[a] |
| Weight (kg) | $70 \pm 12$[a] |
| Incontinence index | $4.4 \pm 2.6$[a] |
| Pad test (mL) | 3.6 [1.0; 13.4][b] |

[a]Mean ± SD.
[b]Median [quartiles].

Eleven women received no medication that affected the urinary tract, 10 women regularly applied local hormones, and 16 women regularly took systemic hormones. Eleven women had undergone surgery for their incontinence. The distribution of types of incontinence was as follows: 28 women had genuine stress, five had urge, and four had mixed urinary incontinence. Nine of the 37 women suffering from urinary incontinence had previously consulted a physician for their problem.

### Functional Testing

Because of atrophic vaginitis two women were unable to perform the cone retention tests. The distribution of the median values of the different functional tests—each evaluated repeatedly within one week—are shown in Table II.

### Reliability

The digital test measuring the contraction time was reproducible with all subjects equally rated at all three measurement times. The absolute difference in maximal contraction force was less than 5.3 mm Hg with a probability of 0.95. The intraclass correlation coefficient (r) comparing the three repeated measurements was 0.97. The absolute difference in mean contraction force within 5 s was less than 4.5 mm Hg with a probability of 0.95. The intraclass correlation coefficient (r) for the mean contraction force was 0.96. In the cone retention test, while walking 19 (54.3%) women held the same cone in place on all three occasions, 13 (37.1%) with a one-cone difference, and 3 (8.6%) with a two-cones difference ($r = 0.93$). During Valsalva's manoeuvre the maximal cone difference was zero for 20 (57.1%), one for 12 (34.3%), two for 2 (5.7%) women, and three for 1 (2.9%) woman ($r = 0.92$).

**TABLE II. Values of Functional Testing**

| | |
|---|---|
| Digital examination | 2 [1;2] |
| Perineometer measurement: maximum contraction force (mm Hg) | 15.3 [8.7; 21.7] |
| Perineometer measurement: mean contraction force (mm Hg) | 10.7 [7.0; 14.0] |
| Cone test: walking | 2 [1; 4] |
| Cone test: Valsalva's manoeuvre | 2 [0; 4] |

Median [quartiles].

**TABLE III. Correlations (r) of Maximum and Mean Contraction Force (Perineometer Measurement) with Other Functional Tests**

| | Perineometer measurement: maximum contraction force | *P* | Perineometer measurement: mean contraction force | *P* |
|---|---|---|---|---|
| Ability to stop urinary stream | 0.88 | 0.0001 | 0.86 | 0.0001 |
| Digital examination | 0.70 | 0.0001 | 0.73 | 0.0001 |
| Cone test: walking | 0.41 | 0.014 | 0.46 | 0.006 |
| Cone test: Valsalva's manoeuvre | 0.46 | 0.006 | 0.48 | 0.003 |
| Pad test | −0.33 | 0.053 | −0.28 | 0.098 |

### Correlations

The maximal contraction force and the mean contraction force during a 5-s contraction showed a high correlation ($r = 0.95$). Both correlated well with the ability to stop the urinary stream and the digital examination, but only weakly with the vaginal cone tests (Table III).

## DISCUSSION

The techniques used in the present study to evaluate PFM strength in elderly women suffering from urinary incontinence were easy to perform. The testing procedure was brief, taking no more than 10–15 min. The digital examination showed no intratester variability. The absolute difference in maximal contraction force and mean contraction force within 5 s of the perineometer measurements were less than 5.3 mm Hg and 4.5 mm Hg, respectively, with a probability of 0.95. In 90% of the women the observed cone difference was less than or equal to one. The maximal contraction force and the mean contraction force within 5 s were very well correlated and each of them showed good correlation with the digital examination. However, correlation with the cone retention tests was weak.

The digital examination, a very easy and quick test, was well tolerated by all patients. The complete absence of intratester variability makes it even better than the results obtained by Wyndaele and Van Eetvelde [1996] who investigated the reliability of digital testing of the PFM in men and found, within an interval of 4 h, no significant differences in strength, endurance, and exhaustion.

Using an intravaginal balloon device, earlier investigations [Dougherty et al., 1986; Bo et al., 1990a] have made reliable pressure recordings when measuring PFM strength in a single subject. The present study showed that when using a perineometer for the assessment of PFM strength, changes greater than 5.3 mm Hg and 4.5 mm Hg may be regarded as true changes in maximal and mean contraction forces, respectively.

In the vaginal cone tests which are also designed to measure PFM strength, only 54% to 57% of the women were able to hold the same cone in place on all three occasions. More than 90% of the women had no- or one-cone difference on all three occasions. Either a disparity between cone size and vagina or different intrasubject PFM tonus during the trials probably had a negative influence on reliability. Hahn and coauthors [1996] found that some women retained heavy cones in spite of a weak pelvic floor. The radiological examination showed that this mismatch was due to the transverse position of the cone in the vagina. Additionally, vaginal atrophy may limit the use of weighted cones [Peattie et al., 1988]. This was the case in two women of our collective.

The perineometer measurements in the present study showed that in untrained individuals, the maximal strength of the PFM correlates very well with its endurance. We do not know how these parameters and their correlations change with regular exercising of the PFM. As maximal contraction of the PFM is needed to stop the urinary stream during micturition, it is not surprising that the maximum contraction force of the perineometer measurement correlated well with the ability to stop the urinary stream. The lesser degree of accuracy of the cone retention tests probably is the reason for the poor correlation between perineometer measurements and the cone retention tests.

A common error in contracting the PFM is to simultaneously contract the adductor, gluteal, and abdominal muscles, which may mask the strength of the PFM contraction [Burgio et al., 1986; Laycock, 1987]. Bo et al. [1990b] have shown that even in experienced women, the electromyographic activity of the lower rectus abdominis muscle increased during maximal PFM contractions. Nevertheless, the authors found that even in inexperienced women, the contraction of muscles other than the PFM did not exceed the pressure rise recorded during PFM contractions alone. However, in order to ensure valid measurement of PFM strength, we first registered the inward lift and squeeze of the muscles by vaginal palpation and then observed the inward movement of the vaginal probe as a sign of correct PFM contraction, which has been described as a 2- to 4-cm upward movement of the perineum [Kegel, 1952].

The perineometer measurement correlated well with the digital examination. However, comparing the two tests, the former has the following advantages: it is a more objective and more precise assessment of pelvic floor activity than

the digital examination. Additionally, it can be used as a biofeedback device [Jones, 1994]. Biofeedback is more effective than verbal feedback based on vaginal palpation for teaching selective sphincter control [Burgio et al., 1986]. This is important, as some women have no or poor perception of a voluntary PFM contraction and because simple verbal or written instruction is not regarded as adequate preparation for a patient to start a PFM program [Bump et al., 1991]. The perineometer provides continuous feedback and information regarding moment-to-moment performance, thus maximising the benefits of physiotherapy. The objective assessment of contractility also encourages patients during treatment. This is very important considering the importance of motivation for the success of treatment.

The majority of women participating in the present study were suffering from stress incontinence, although urge incontinence is supposed to be the most common type of urinary incontinence in the elderly [Castleden et al., 1981]. The fact that some women had mixed incontinence is not surprising, as this is especially common in the elderly [Fossberg et al., 1991].

Some women regularly took medication that affected the urinary tract and some had a history of incontinence surgery. However, this was of no significance as every woman was compared with herself. The diverse results of the pad test are an expression of the variation in the women's severity of urinary incontinence. To keep the collective as homogenous as possible, we only included postmenopausal women. It has been proposed that the prevalence of urinary incontinence is higher in the perimenopause, but this could not be verified [Dolan et al., 1999]. However, it is known that ageing may affect the lower urinary tract in several ways, creating a predisposition to incontinence [Resnick and Yalla, 1985]. Ageing is associated with a reduction in speed, strength, and duration of skeletal neuromuscular reactions and a decreased strength of skeletal muscle [Carlson, 1949].

As previous research and clinical observations have indicated that intravaginal pressure may fluctuate during the day [Dougherty et al., 1991], we paid attention to the slightest within-subject variation. For this reason, data were collected at the same time of the day for all three tests.

We did not consider an interrater reliability for the assessment tools because, as a rule, patients should be instructed and the therapy should be evaluated by a single investigator. Furthermore, the digital examination has already been shown to correlate well between experienced and inexperienced examiners [Ryhammer et al., 1999].

## CONCLUSION

As PFM function is easy to assess, it should be routinely done in the clinical assessment of elderly women with urinary incontinence. The reliability of PFM strength measurement is highest in the digital examination, followed by perineometer measurements, and then by vaginal cone tests.

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