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Pelvic Floor Maximal Strength Using Vaginal Digital Assessment Compared to Dynamometric Measurements

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Aim: To compare vaginal digital assessment with dynamometric measurements for determining the maximal strength of the pelvic floor muscles (PFM). **Materials and Methods:** Eighty-nine women aged between 21 and 44 participated in the study. An experienced physiotherapist evaluated the maximal strength of the PFM of these women using the modified Oxford grading system (six categories, range 0–5) and dynamometric measurements. The mean maximal forces obtained for all women with the instrumented speculum for each category of digital assessment were compared using ANOVAs. Spearman's rho coefficients were calculated to assess the correlation between the dynamometric and the digital assessments. **Results:** According to their symptoms and pad test results, 30 women were continent and 59 had stress urinary incontinence (SUI). Based on dynamometric measurements, important overlaps were observed between each category of digital assessment. The ANOVAs indicated that force values differ across categories ($F = 10.08$; $P < 0.001$), although contrast analyses revealed no differences in the mean maximal forces between adjacent digital-assessment categories (1–2, 2–3, 3–4, 4–5). Mean force values differed significantly only between non-adjacent levels in digital assessment, for example, between 1 and 3; 1 and 4; 1 and 5; 2 and 4; 2 and 5 ($P < 0.05$). Significant correlations were found between the two measurements with coefficients of $r = 0.727$, $r = 0.450$, and $r = 0.564$ for continent, incontinent, and all women, respectively ($P < 0.01$). **Conclusions:** Even if the dynamometric mean forces of the PFM increased across subsequent categories of digital assessment, the force values between two adjacent categories do not differ. This limitation of digital assessment should be considered by clinicians and researchers when choosing treatment orientation and evaluating treatment outcomes. *Neurourol. Urodynam. 23:336–341, 2004.* © 2004 Wiley-Liss, Inc.

Key words: dynamometer and vaginal palpation; pelvic floor musculature; strength evaluation; stress urinary incontinence

INTRODUCTION

Physiotherapy is recommended as a first line of treatment for stress urinary incontinence (SUI) [Fantl et al., 1996; Wilson et al., 2002]. Strengthening of the pelvic floor muscles (PFM) is the major goal of these conservative, albeit effective, treatments [Hay-Smith et al., 2002]. Consequently, assessment of the PFM strength is essential for evaluating treatment outcomes and identifying patients who would benefit from such conservative treatment. Furthermore, PFM assessment has been strongly recommended by the International Continence Society (ICS) as part of a routine examination for women complaining of lower tract urinary symptoms [Schull et al., 2002]. For this purpose, in the practices of obstetrics, gynecology, urology, general medicine, and physiotherapy, clinicians often rely on vaginal digital assessment because it is quick and requires no equipment. Several scoring systems have been developed to quantify PFM strength [Worth et al., 1986; Laycock, 1992; Brink et al., 1994]. The modified Oxford grading system, inspired by a six-category muscle strength quotation widely used by physiotherapists for various muscle groups, has been applied to the PFM. Based on that grading system, Peschers et al. [2001] advanced that digital assessment can assess PFM strength directly and differentiate pelvic floor musculature from other muscle compensations such as abdominal, adductor and gluteal muscle contractions. Moreover,

Abbreviations: EMG, electromyography; ICS, International Continence Society; PFM, pelvic floor muscles; SUI, stress urinary incontinence.

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the modified Oxford grading system has shown good test–retest reliability with a Pearson correlation coefficient of 0.947 ($P < 0.001$) [Laycock, 1992].

Digital assessment of the pelvic floor has already been compared to other techniques in order to verify its validity. Some studies have found a good relationship between this type of assessment and intra-vaginal pressure measurements [Hahn et al., 1996; Kerschan-Schindl et al., 2002] while another study showed no significant relation [Bo and Finckenhagen, 2001]. The controversy may be partly explained by the influence of intra-abdominal pressure, which is arguably an important artefact to PFM pressure measurements [Hahn et al., 1996; Peschers et al., 2001]. Moreover, digital assessment has been correlated moderately with PFM electromyography (EMG) [Brink et al., 1994; Romanzi et al., 1999]. It should be pointed out that EMG reflects pelvic floor myoelectric activity, although this is not a direct measurement of maximal strength. These measurements may be contaminated by the activity of neighboring muscles (non-PFM recordings) such as adductor and gluteal muscles [Peschers et al., 2001]. To date, digital assessment has never been compared to direct measurements of PFM strength.

The aim of this study was to compare two techniques to evaluating PFM maximal strength: vaginal digital assessment and force measurements obtained by a new dynamometer designed to record the PFM function both directly and specifically. It was hypothesized that mean forces obtained with the dynamometer would differ for each digital assessment category. Moreover, a good relation between the two measurements was expected.

MATERIALS AND METHODS

Subjects

Eighty-nine women, aged between 21 and 44, were recruited from the obstetrics and gynecology clinic of Sainte-Justine Hospital. In accordance with the ICS definition of SUI as the complaint of involuntary leakage on effort or exertion, or on sneezing or coughing [Abrams et al., 2002], 59 women reported symptoms and 30 were symptom-free. Parity being strongly associated with the onset of SUI in middle-aged women [Rortveit et al., 2001], the participants included in the study had experienced at least one vaginal delivery. A minimum of 3 months between delivery and assessment was respected considering that PFM recovery has been shown to be completed within 2 months post-partum [Peschers et al., 1997]. Exclusion criteria were pregnancy, menstruation on the day of assessment, urgency, anterior urogynecologic surgery, major organ prolapse, active urine, or vaginal infection, excessive vaginal scarring, or any other disease that may interfere with pelvic floor strength measurements. All women gave written consent to participate in the study, which was approved by the Ethics Committee of Ste-Justine Hospital.

Initial Assessment

To confirm SUI, symptomatic subjects (n = 59) underwent a medical and a urodynamic evaluation. The absence of detrusor overactivity was then demonstrated by cystometry. Incontinence symptoms were assessed using the Urogenital Distress Inventory questionnaire [Shumaker et al., 1994]. A modified 20-min pad test with standardized bladder volume (250 ml) was also performed to verify and quantify the symptoms (Table I) [Abrams et al., 1988; Sand, 1992]. To prove continence, asymptomatic women (n = 30) were also assessed by the 20-min pad test and the Urogenital Distress Inventory questionnaire. However, to reduce the invasiveness of the artificial bladder filling associated with the standardized bladder volume, the latter was measured by ultrasound with the Bladder Scan 3000 (Diagnostic Ultrasound). One hour before the test, the subjects were asked to drink 1 L of water. The pad test was carried out when the bladder contained more than 250 ml, which corresponded to the bladder volume of the incontinent subjects. In interpreting the results, subjects with a pad weight gain up to 1 g, which may be due to weighing errors, sweating, or vaginal discharge, were considered continent [Abrams et al., 1988; Artibani et al., 2002].

Digital PFM Testing

The assessment was conducted entirely by an experienced physiotherapist who does the modified Oxford digital assessment routinely in her own practice. Considering that the bladder-filling procedure used for pad testing was different for each group, the physiotherapist was informed about the continence status of the participants. After emptying her bladder, each subject adopted a supine lying position with hips and

TABLE I. Modified 20-min Pad Test

Test schedule
1. (a) For symptomatic women, the bladder is emptied with a transurethral catheter and then filled to a bladder volume of 250 ml.
(b) For asymptomatic women, 1 L of water is drunk 1 hr before the test. The pad test is performed when the bladder contains more than 250 ml assessed by ultrasound.
2. Pre-weighed collecting device is put on.
3. Over a 10-min period, subject walks, including stair-climbing equivalent to one flight up and down.
4. During the remaining period the subject performs the following activities:
Standing up from sitting, ten times.
Coughing vigorously, ten times.
Running on the spot for 1 min.
Bending to pick up small object from floor, five times.
Jumping jack, ten times.
Washing hands in running water for 1 min.
5. At the end of the 20-min pad test, the collecting device is removed and weighed.

knees flexed, feet flat on a conventional gynecologist's table. Instructions about contracting the PFM were given. The physiotherapist put on gloves and applied a lubricating gel. Then, the two distal phalanges of the index and the middle finger were inserted in the introitus vagina and positioned laterally in order to evaluate both sides of the PFM. The subjects were asked to squeeze and lift their PFM as if preventing the escape of flatus and urine while breathing out [Laycock, 1994]. The evaluator made sure the subject performed the contraction adequately. The contraction was then graded from 0 to 5 according to the modified Oxford grading system [Laycock, 1992]. The definition of each grading category is given in Table II.

Dynamometric Measurements

A new dynamometer designed specifically to evaluate the pelvic floor musculature was used in this study to measure the pelvic floor maximal strength. A detailed description of this instrument has been reported elsewhere [Dumoulin et al., 2003a]. Briefly, the dynamometer comprises a computerized central unit and a peripheral unit, a dynamometric speculum. The dynamometric speculum comprises two aluminum branches (Fig. 1). The upper branch is fixed, the other, equipped with strain gauges, can be moved by an adjustable screw allowing measurements to be taken for different vaginal apertures. The differential arrangement of the strain gauges ensures that the force is measured independently of the exact site of application of the resultant force to the lower branch of the speculum in the vagina. This feature is primordial in evaluating the PFM function because the exact site of the resultant force applied to an intra-vaginal speculum can vary between measurements as between subjects [Dumoulin et al., 2003a].

For the dynamometric measurements, the subjects were evaluated by the physiotherapist in the same position as for the digital assessment. A single physiotherapist performed both the digital and the dynamometric assessments. It should be noted that digital evaluation always precedes dynamometric testing. Thus, the subjective estimation based on digital assessment cannot be affected by the objective dynamometric results. The inverse (dynamometry before digital evaluation) could be more susceptible to bias. Prior to the insertion of the speculum into the vaginal cavity, each branch was covered with a condom and appropriately lubricated with a hypoallergenic gel. To ensure correct positioning of the device, the two closed branches were inserted into the vagina until the mark on the upper branch was level with the hymenal ring. The device was positioned at a depth of 5 cm, allowing assessment of the entire pelvic floor musculature, located approximately 3.5 cm from the opening of the vaginal cavity [Bo, 1992]. The speculum remained closed with a minimal distance of 5 mm between the two branches. Considering the thickness of the two branches (6 mm for the upper branch and 8 mm for the lower one), the minimal opening corresponded to a vaginal aperture of 19 mm (antero-posterior diameter). Since PFM strength increases with opening [Dumoulin et al., 2003b], a dynamometric assessment of the pelvic floor was performed at minimal opening in order to reproduce the same vaginal aperture as in the digital assessment. Moreover, minimal branch opening has shown good test–retest reliability with an index of dependability reaching 0.71 [Dumoulin et al., 2001, 2003b]. To ensure that the women were comfortable and to familiarize them with the device inserted, they were asked to perform three unrecorded practice pelvic floor contractions. Before making the effort, the subjects were instructed to relax their PFM so that a baseline value could be recorded. They were then asked to contract as they did in the digital examination. Three 10-sec contractions separated by a 2-min rest period were recorded. Standardized verbal encouragement was given throughout the effort [Caldwell et al., 1974]. The maximum strength value (maximum peak value minus baseline value) was extracted for each trial (Fig. 2). The mean of the three trials was calculated and used in all statistical analyses.

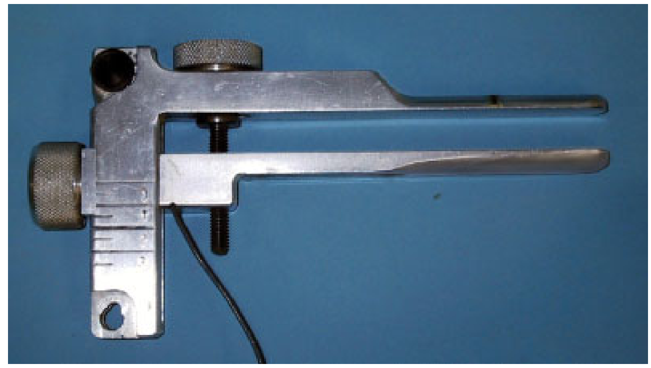

Fig. 1. Dynamometric speculum.

TABLE II. Modified Oxford Scale for Digital Evaluation of Pelvic Floor Contraction Strength

Grade	Description
0	Nil
1	Flicker
2	Weak
3	Moderate, slight lift of the examiner's fingers, no resistance
4	Good, sufficient to elevate the examiner's fingers against light resistance
5	Strong, sufficient to elevate the examiner's fingers against strong resistance

Statistical Analysis

The mean dynamometric value was computed for each category of the modified Oxford grading system and compared using a one-way ANOVA followed by the post-hoc Scheffe method to locate significant differences between pairs of assessment categories. A probability level of 0.05 was chosen. The correlation between the vaginal digital assessment and the

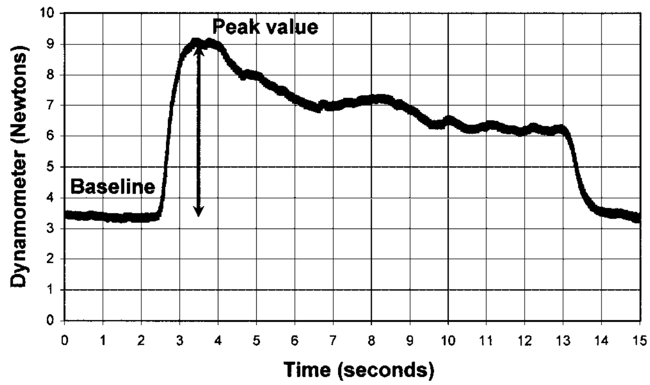

Fig. 2. Strength curve.

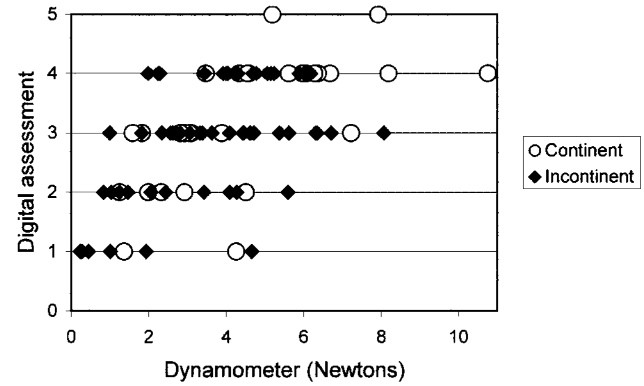

Fig. 3. Distribution of results obtained when comparing the dynamometer and digital assessment.

dynamometric measurements was determined by Spearman's rho. Because the range of values was expected to be different between continent and incontinent subjects, the correlations were calculated separately for each group of women.

RESULTS

Based on both reported symptoms and the pad test, 30 women were continent and 59 incontinent. Hence, continent women (n = 30) reported no symptoms of urinary incontinence and demonstrated non-significant leakage (<1 g) in the pad test whereas all the asymptomatic women proved to be continent in the pad test. Women suffering from SUI (n = 59) lost 35.2 g (±55.4 standard deviation (SD); 5–309) in the pad test. Mean age, body mass index, and deliveries are shown in Table III. There were 25 primipara (28.1%) and 64 multipara (71.9%).

The distribution of the dynamometric assessments for both continent and incontinent women is shown in Figures 3 and 4 for each category of the Oxford grading system. Except for the highest quotation (5), where no value is present for incontinent women, the dynamometric data of both groups cover about the same range in each category. Moreover, the means of the dynamometric measures were 1.8 N; 2.6 N; 3.9 N; 5.0 N; 6.5 N for digital assessment grades 1, 2, 3, 4, and 5, respectively. The ANOVA indicates that the mean forces increase across categories ($F = 10.08$; $P < 0.001$) although substantial overlapping of values is observed between categories. Contrast analyses using the Scheffe method are shown in Table IV. No significant differences were found between adjacent digital assessment categories such as 1–2; 2–3; 3–4; 4–5. ANOVAs had revealed differences only between than two assessment grades and more ($P < 0.05$). Thus, grade 1 was different from grades 3, 4, and 5. Grade 2 could be distinguished from grades 4 and 5. As an exception to that pattern, the difference between grades 3 and 5 did not reach a significant level. This may be explained by the small number of subjects (n = 2) who scored 5 on the modified Oxford grading system.

The results of the correlation analyses for all women showed a moderate relation between the two techniques, with a Spearman's coefficient of $r = 0.564$ ($P = 0.01$). In continent women, a higher correlation was observed, with a coefficient of $r = 0.727$ ($P = 0.01$) whereas in incontinent women a weaker relation between the two techniques was found, with a coefficient of $r = 0.450$ ($P = 0.01$).

TABLE III. Characteristics of Women (Mean ± Standard Deviation (SD); Range in Parentheses)

	All subjects (n = 89)
Age (years)	34.7 ± 4.7 (21–44)
Body mass index (kg/m^2)	23.9 ± 3.7 (18.7–43.3)
Deliveries	2.0 ± 0.9 (1–4)

DISCUSSION

The limitations of the digital assessment were highlighted by our results on the overlapping of dynamometric values between adjacent assessment grades. Overlaps in the PFM

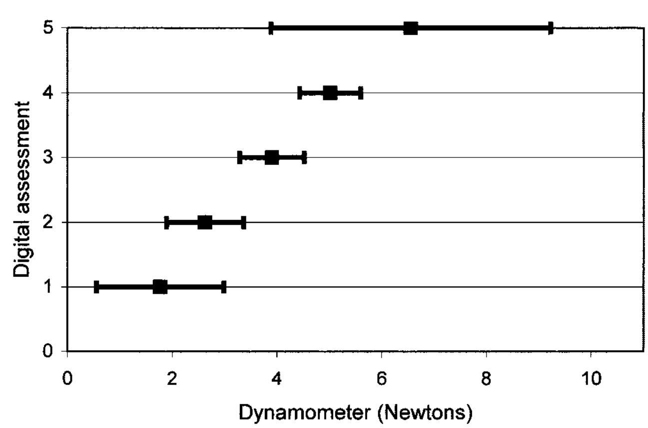

Fig. 4. Mean muscle strength with 95% confidence interval in the categories assessed by the Oxford grading system for all subjects (both continent and incontinent women).

TABLE IV. Results From ANOVAs Post-Hoc Using Scheffe Method (Significant *P* values are indicated by an asterisk in the Table Cells)

	1 (n = 8)	2 (n = 15)	3 (n = 31)	4 (n = 33)	5 (n = 2)
1	—	0.85	0.05	0.00*	0.02*
2		—	0.23	0.00*	0.05*
3			—	0.15	0.34
4				—	0.81
5					—

digital assessment had already been reported [Bo and Finckenhagen, 2001] and, also, in the manual muscle testing of the extremities [Beasley, 1956; Noreau and Vachon, 1998]. The limited capacity of the assessment method to reveal the true strength difference has an important consequence on the ability of a digital assessment to detect changes over time and/or after treatments (responsiveness). Recently, Jundt et al. [2002] reported no difference in PFM strength before and after childbirth as assessed by the modified Oxford grading system. Furthermore, some studies had reported that after physiotherapy for SUI, a reduction in urinary leakage occurred while no improvement in the pelvic floor maximal strength was actually demonstrated [Blowman et al., 1991; Laycock and Jerwood, 1993]. A similar lack of sensitivity has been demonstrated in the extremities: the strength gain measured by the dynamometer was not detected by manual testing [Schwartz et al., 1992; Herbison et al., 1996]. Moreover, it has been shown that in the case of the extremities dynamometric measures are preferable in a research setting because smaller sample sizes suffice to yield significant results [Aitkens et al., 1989]. The sensitivity of digital assessments to change is questionable. It is important to note that the reported significant difference between assessment levels is applicable only to mean values of group and not to individual measurements. In fact, the large amount of overlapping of values across categories actually determines the high probability of misclassification. For example, as illustrated in Figure 3, two subjects with the same dynamometric strength can be classified in three or four different digital-assessment categories.

Only a few women scored 0, 1, and 5, creating a bias in our sample. However, other studies have reported similar distributions of the digital scores with a higher percentage for scores of 3 and 4, while less than 10% scored 0, 1, and 5 [Isherwood and Rane, 2000; Bo and Finckenhagen, 2001]. Even if the distribution of digital scores was similar in these two studies, their samples concerning the continence status were different. Actually, Isherwood and Rane [2000] had studied incontinent women while Bo and Finckenhagen [2001] studied mainly continent women (65%). Furthermore, a similar distribution was found in the extremities (knee extension strengths in patients with osteoarthritis) with 79% of subjects scoring 3 and 4 [Hayes and Falconer, 1992].

The correlations found between digital assessments and dynamometric measurements can be defined as moderate to good according to the standards proposed by Portney and Watkins [2000]. Our results are similar to those of Laycock [1992], who found a Spearman's coefficient of 0.78 between the modified Oxford grading system and pressure perineometry in continent women. In contrast, Bo and Finckenhagen [2001] found no significant relation between the two latter techniques. However, the correlation coefficient was not reported and the authors argue that the lack of correlation may be due to the small sample size of the study (n = 20).

CONCLUSIONS

A significant relation between digital and dynamometric assessments was observed. Even if the dynamometric mean forces of the PFM increased across subsequent categories of digital assessment, it appears that subjective appreciation of force level by digital evaluation (either across patients or following treatments) is possible only when large differences of force exist. This limitation should be considered by clinicians and researchers when choosing treatment orientation and evaluating treatment outcomes.

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