Objective Assessment of the Overactive Pelvic Floor

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11.1 Introduction

Pelvic floor muscle (PFM) overactivity is recognized as playing a crucial role in several conditions such as bladder and bowel elimination disorders, genital/pelvic pain syndromes, and sexual dysfunctions and, thus, its objective assessment is key to a better understanding of the ongoing pathophysiological processes and critical for properly orienting treatment.

An adequate assessment calls for a thorough comprehension of the muscle physiology underlying muscle tone. As discussed in detail in Chap. 1, general muscle tone, sometimes referred as muscle tension, is a complex phenomenon that can be defined as the resistance provided by the muscle when pressure or a stretch is applied. In normally innervated skeletal muscle, muscle tone is composed of a passive and an active component [1]. The passive component consists of the viscoelastic properties of the muscle tissue related to several structures [2]: (1) the extensibility of actin-myosin cross-bridges (EMG silent); (2) noncontractile cytoskeleton proteins such as the desmin and the titin and (3) conjunctive tissues surrounding the entire muscle (epimysium), muscle fascicle (perimysium), and muscle fiber (endomysium). The active component, in turn, comprises physiological contracture (more commonly defined as trigger point (TP)), electrogenic spasms (which include unintentional muscle contraction with or without pain amenable to voluntary control), and normal electrogenic contraction (involves resting activity in normally relaxed muscle and also myotatic reflex during stretching). Only electrogenic spasms and normal electrogenic contractions involve electrical current propagating along muscle fibers that can be recorded by electromyography (EMG). It has been reported that electrogenic spasms may be related to psychological distress (e.g., anxiety), muscle overload or overuse (due for instance to inadequate posture) and inefficient uses (e.g., failure to fully relax after contraction) [1]. It should be pointed out that the presence of resting activity in normally relaxed muscle is controversial. While studies in skeletal muscle failed to find evidence of resting EMG [3, 4], the PFMs may be an exception as Deindl et al. [5] suggested that some part of the levator ani may present sustained motor unit firing at rest. The term "overactive" describing the pelvic floor may refer to an elevated "electrogenic" resting activity. Throughout this chapter, the objective assessment will be discussed in a wider context of heightened PFM tone as the available literature suggests that the pathophysiology is not limited

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to an electrogenic mechanism. A clear understanding of muscle tone physiology and its active/passive components is mandatory and must be related to the characteristics and limitations of the current PFM assessment tools. For instance, it is of the utmost importance to know which muscle tone component is assessed by each assessment method in order to better understand the role of the PFMs in the patient's symptomatology, presumably associated with an overactive pelvic floor.

In conditions due to overactive pelvic floor, several authors emphasize that elevated PFM tone might not be the only muscle dysfunction and stress the importance of a broader assessment of muscle contractile properties [6–11]. The assessment should therefore go beyond the properties of the muscles at rest to evaluate the contractile properties such as strength, endurance, and speed of contraction.

Several assessment tools and methodologies are available for assessing PFM tone and contractile properties, namely digital palpation, EMG, ultrasound imaging manometry and dynamometry. This chapter reviews these tools in light of muscle physiology (components of tone, for instance) and provides an overview of the psychometric properties (reliability and validity) of the instruments for measuring tone and other PFM contractile properties as well as discussing their limitations. The scientific empirical evidence available related to the implication of the PFMs in men and women with overactive pelvic floor will also be presented.

11.2 Vaginal Palpation

Digital palpation of the PFMs is widely used to evaluate the PFM tone and contractile properties such as strength, endurance, speed of contraction, and coordination [6–9, 12–14]. Although contested as an assessment method for research purposes because of its subjectivity and lack of precision, digital palpation is a fast and practical technique easy to implement in a clinical setting.

Palpation can be used for an overall subjective appraisal of the PFM tone. The examination may start with external palpation to assess the patient's anticipatory and protective reactions, appreciate PFM tone, and detect pain mainly at PFM insertion sites (pubic arch, ischial tuberosity, and coccyx). In cases where intracavity measurement is not possible, the clinician relies entirely on this assessment approach. Intravaginal palpation can be performed in a clockwise manner for detecting pain/tenderness, tension areas, muscle volume, asymmetry, reduced sensation, and scars. Palpation of the obturator internus muscle may also reveal tenderness and tensions. Transrectal palpation can provide a similar overview of the external anal sphincter and levator ani muscles in addition to assessing the coccyx position and mobility, anorectal angle (related to puborectalis tone), and rectal content. Although claimed essential for clinical practice, there is a paucity of evidence regarding the validity and reliability of this global subjective assessment of PFM tone.

11.2.1 Grading Scale for Assessing PFM Tone

Some grading scales have been developed in an attempt to quantify the PFM tone. *Devreese's tone grading scale*, developed in a context of assessing women with incontinence, comprises just three levels (hypotonic/normotonic/hypertonic) for intravaginal assessment [14]. Despite a good interrater reliability (agreement in 96–98 % of patients), the limited number of levels may be less relevant for assessing overactive PFMs. Also developed in women with incontinence and prolapse, *Dietz's tone grading scale* [15], ranging from 0 to 5, shows a moderate test–retest reliability (weighted kappa (K) = 0.55), see Table 11.1 for assessing the PFM tone. Using this scale in asymptomatic women, Loving et al. [9] obtained a higher test–retest reliability (K = 0.7–1.0) and a good interrater reliability (K = 0.7–0.8). The main limiting factor for this quotation is that the grading system incorporates three components, namely hiatus size, resistance to distension, and pain. A woman with pain will thus automatically obtain the highest score of 5.

Table 11.1 Dietz's tone grading scale [15]

Grade	Description
0	Muscle not palpable
1	Muscle palpable but very flaccid, wide hiatus, minimal resistance to distension
2	Hiatus wide but some resistance to distension
3	Hiatus fairly narrow, fair resistance to palpation but easily distended
4	Hiatus narrow, muscle can be distended but high resistance to distension, no pain
5	Hiatus very narrow, no distension possible, "woody" feel, possibly with pain: "vaginismus"

Table 11.2 Lamont's tone grading scale developed in women with vaginismus [16]

Grade	Description
0	Normal muscle tone
1	Perineal and levator spasm (released by reassurance)
2	Perineal spasm maintained throughout the pelvic exam
3	Levator spasm and buttocks elevation
4	Levator and perineal spasm, elevation: adduction of thighs and pelvic withdrawal

Lamont developed a scale (from 0 to 4) for assessing PFM tone in women with vaginismus [16]. Similarly, the scale also includes components other than PFM tone such as hip muscle contractions and withdrawal behaviors (Table 11.2). This scale has not been studied for its psychometric properties and the assessment of combined components may affect the validity of the test for evaluating PFM tone.

Ressing et al. [8] proposed a 7-level scale ranging from +3 very hypertonic to −3 very hypotonic (0 being normal tone) for assessing women with provoked vestibulodynia. Superficial layers of the PFM, including the ischiocavernosus, bulbocarvernosus and transverse superficial, can be assessed by intravaginal palpation at 3, 6, and 9 o'clock. The deeper PFM layers are evaluated at 3, 6, and 9 o'clock for the pubococcygeus sling and 5 and 7 o'clock for the iliococcygeus. The anal examination comprises an evaluation of the external anal sphincter on a scale of 1 (hypotonic), 0 (normal) and +1 (hypertonic) and the puborectalis/pupoccoccygeus on a scale from +3 to −3 as described in above, the right and left side being evaluated separately. This scale has been studied for its interrater reliability and, overall, a fair-to-moderate reliability was found with correlation coefficients of 0.230–0.514 [8]. Considering the available evidence about reliability and the specificity of the grades assessing only tone component, Reissing's scale is probably the most suitable in a context of assessing heightened PFM tone. With reference to muscle physiology, assessment of PFM tone using these scales evaluates the total contribution of all active and passive components of muscle tone. In other words, it cannot distinguish between specific sources of muscle tone.

11.2.2 Flexibility and Hiatus Diameters

Measurement of flexibility and hiatus diameters has been suggested as a means to assess the maximal PFM length. The distance between the left and right muscle bellies just below the pubic bone is estimated in centimeters by separating two fingers inserted in the vagina (transverse hiatus diameter) [17]. The distance between the back of the pubic symphysis and the midline raphe of the puborectalis is also measured (anteroposterior diameter). Boyles et al. [17] found a good-to-excellent interrater reliability with correlation coefficients of 0.6–0.8. Likewise, Gentilcore et al. [6] assessed the transverse diameter by grading from 0 (less than one finger insertion) to 4 (two-finger insertions with fingers abducted horizontally ≥2 cm). However, this scale was not studied for its validity and reliability. Maximal muscle length measurement is commonly performed in a general skeletal muscle assessment and is determined by the patient's tolerance and increases in EMG in order to ensure adequate muscle relaxation during stretching. Because such monitoring is obviously not part of a palpation assessment, these scales are considered as a global measurement of PFM tone without discriminating between active and passive components.

11.2.3 Relaxation Ability After a Maximal Contraction

The International Continence Society (ICS) stadardization group on PFM function and dysfunction recommended assessing the PFM relaxation ability after a contraction [18]. They suggested describing the relaxation as present/absent and partial/complete [18]. Loving et al. [9] studied the test–retest and interrater reliability of this scale in asymptomatic women and found a kappa of 1.0 and 0.60, respectively. Lower test–retest and interrater reliability was observed by Slieker-ten Hove et al. [13], however, with a weighted kappa of 0.76 and 0.17, respectively. In addition to these qualifiers, Reissing et al. [8] suggested documenting the speed of relaxation (slow/fast). Although not studied for its psychometric properties, a scale developed in women with multiple sclerosis was proposed by De Ridder et al. [19] for grading the ability to relax the pelvic floor: 3—active relaxation after active contraction, 2—hypertonic muscle with temporary relaxation after elongation, 1—spastic muscle, unable to relax even after passive elongation. Reissing et al. [8] proposed a scale to grade the relaxation from 0 to 5 (0 returns to resting state; 5 remains fully contracted). Fair interrater reliability was observed only when the assessment was performed using two fingers ($r = 0.355–0.400$) as opposed to one finger, which yielded unreliable data. Although not studied for reliability, a similar scale was proposed by Gentilcore et al. [6] evaluating the relaxation capacity on a 5-point scale from 0 (which indicated the PFMs were fully able to return to their resting state following a maximal contraction or 100 % relaxation) to 4 (which indicated that the PFMs remained fully contracted after a maximal contraction or 0 % relaxation). One limitation related to these scales is that the scoring refers to the resting state observed before contraction. This is particularly problematic in the case of elevated tone at baseline, whereas a patient would be categorized as having a good relaxation if she returns to the pathological precontraction level.

11.2.4 Myofascial Trigger Point Assessment

The myofascial trigger point (TP) is defined as an identifiable taut band or rope-like indurations palpated in the muscle fiber that can evoke pain both locally (local tenderness) and at distant reference-pain zones specific to each TP [20]. With regard to the muscle physiology [1], TP refers to physiological contracture, one element among the active components of muscle tone. It should be emphasized that TP refers to an endogenous shortening of a specific point in a muscular fiber which is not detectable by global EMG. TP assessment has been deemed important not only because it is associated with pain but it has also been reported that TP can provoke heightened PFM tone (related to electrogenic spasms) [21]. It has been shown that manual therapy for releasing TPs results in PFM relaxation as measured by the reduction in resting EMG activity (i.e., reduction of the electrogenic spasms) [21].

Kavvadias et al. [22] investigated the intensity of pain elicited during palpation of TPs in the anterior levator ani, posterior levator ani, obturator internus and piriformis on both sides using a visual analog scale. They obtained a heterogeneous test–retest and interrater reliability with ICCs of 0.20–0.87 and 0.28–0.87, respectively, in a sample of asymptomatic women. Palpation of the posterior levator ani showed a higher reliability than the anterior portion [22]. Montenegro et al. [23] studied the interrater reliability of the tenderness assessment of the bilateral levator ani, piriformis, and internal obturator muscles in controls and women with chronic pelvic pain. Tenderness was scored according to each subject's reactions for the six positions as follows: 0, no pain; 1, painful discomfort; 2, intense pain; with a maximum total score of 12. Very good interrater reliability was found with a kappa of 0.91. A systematic review about TP in limbs and trunk muscle pointed out that TP assessment should not be limited to tenderness but should notably include taut bands, patient pain recognition, and pain referral [24]. It should be noted that TPs located in the levator ani have referral zones in the muscle and in both anterior and posterior compartments (rectum, anus, coccyx, urethra, bladder, penis/vulva, buttocks). The obturator internus and piriformis can, in turn, refer to the perineal zone. More information about referred pain patterns in the PFMs and surrounding muscles can be found elsewhere [20, 25, 26]. Hsieh et al. [27] pointed out that the evaluator's experience might influence the psychometrics of TP assessment. In sum, considering that psychometric studies so far have focused mainly on pain intensity with divergent findings, the assessment of TP using digital palpation warrants further investigation.

11.2.5 Contractile Properties

Current evidence in patients with heightened PFM tone converges toward the presence of other concomitant alterations in contractile properties. It is generally recognized that the PFMs are difficult to contract correctly. In fact, even among women without urogynecological problems, over 30 % are unable to adequately contract these muscles following verbal instructions and need further teaching such as vaginal palpation [28]. To facilitate PFM contraction, Messelink et al. [18] suggested instructing women to "squeeze and lift as if to prevent the escape of gas or urine." Crotty et al. [29] demonstrated that verbal cues that included both the anterior and posterior parts of the PFMs yielded stronger contractions: "Squeeze and lift from the front and back together." Palpation was also suggested to be useful in teaching women to perform adequate PFM contraction avoiding muscle compensation such as buttock, adductor, rectus abdominus contraction as well as perineal inversion (i.e., straining) [30, 31].

Several scales have been proposed to grade the PFM contractile properties including Brinks' scale [32], Devreese's scale [14] and Messelink's scale [13, 18] as well as the Laycock PERFECT assessment scheme, which incorporates the modified Oxford scale [12]. In general, these scales show an acceptable intra-observer and test–retest reliability [9, 13, 14, 32–36]. The modified Oxford scale seems to be the most frequently used in women with chronic pain conditions [6–9, 37]. The Laycock PERFECT assessment scheme, presented in Table 11.3, proposes an assessment of strength and endurance, the number of repetitions and fast contractions. It has been shown that this grading system can be used with different patient positions, lying or upright, with good reliability [34], although it was found that women prefer the supine position for internal examination [38]. Furthermore, the reliability of the modified Oxford scale has also been investigated when a "+" or "–" is added to the original quotation but it was found that the original 6-level quotation (without +/–) yielded better reliability. It was recommended by the ICS standardization group on PFM function and dysfunction to limit the number of levels in a strength-assessing scale to preserve an acceptable interrater reliability [18]. On the other hand, this limitation may interfere with the responsiveness to detect differences between individuals and changes following treatment [31].

Table 11.3 The Laycock PERFECT scheme [12]

Scale	Description
P	*P*ower
	0—Nil
	1—Flicker
	2—Weak
	3—Moderate
	4—Good
	5—Strong
E	*E*ndurance is expressed as the length of time, up to 10 s, that a maximal voluntary contraction can be sustained before the strength is reduced by 35 % or more
R	Number of *R*epetitions that a woman is able to achieve (same duration as in E)
F	Number of *F*ast (1-s) maximal contractions performed (up to 10)
E	*E*very
C	*C*ontraction
T	*T*imed (to complete the acronym and reminds the examiner to time and record the above sequence of events)

11.2.6 Overall Considerations

Digital palpation assessment of PFMs can be performed by inserting one or more fingers inside the vagina [6–8]. In chronic pain patients, the presence of pain associated with vaginal distention can bias PFM tone assessment by provoking protective-like muscular reactions and thus result in heightened PFM tone and incomplete relaxation [7, 39]. It is also possible that strength reduction is caused by pain inhibition. Despite the influence of pain on muscle assessment, it is already known from studies both of skeletal muscle and of PFMs that muscle lengthening (i.e., by inserting a finger) resulted in higher muscle strength during voluntary contraction as well as superior passive forces recorded at rest [2]. In our population of interest, it is probable that pain and muscle lengthening affect digital palpation scoring.

In sum, although digital palpation is contested for research purposes because of its subjectivity, it is widely used in clinical settings as it is practical, low-cost, and easy to apply. This tool provides important insight into PFM tone including flexibility, relaxation abilities, and TPs as well as PFM contractile properties. Its use for clinical practice is suggested for evaluating PFM dysfunctions, detecting surrounding muscle compensations, identifying tenderness area, and also orienting treatment.

11.2.7 Evidence in Women and Men with Heightened PFM Tone Using Digital Palpation

The involvement of the PFMs in dyspareunia, especially in provoked vestibulodynia, has been evaluated using digital palpation. Women with provoked vestibulodynia showed higher tone, as assessed with Reissing's scale, in comparison with asymptomatic controls [6–8]. Similar findings were also obtained using Lamont's scale [16]. Lower relaxation capacity and reduced flexibility were also found in women with provoked vestibulodynia [6] as assessed with the aforementioned scales (i.e., relaxation 0 returns to resting state—4 remains fully contracted; flexibility 0 one finger to two fingers abducted more than 2 cm) [6]. Regarding PFM contractile properties, women with provoked vestibulodynia were also found to have lower PFM strength measured with the modified Oxford grading scale [6–8]. Likewise, women with chronic pelvic pain had higher PFM resting tone (Dietz's scale) and decreased maximal PFM strength (modified Oxford grading scale) and relaxation capacity (absent/complete/partial) compared with pain-free controls [9]. Conversely, Fitzgerald et al. [37] did not find any significant difference regarding muscle strength (modified Oxford grading system) in women with and without chronic pelvic pain in a slightly smaller sample. As mentioned earlier, it is not possible to elucidate with palpation alone whether the reduction of pain results from a true weakness or from pain inhibition.

Studies concurred about the importance of muscle tenderness and TPs in women with chronic pelvic pain. The prevalence of TPs in the PFMs and surrounding muscles (e.g., obturator internus, piriformis) ranged from 63 to 89 % in women with chronic pelvic pain (including interstitial cystitis), which was significantly higher than in asymptomatic controls [23, 26, 37, 41–43]. Interestingly, Montenegro et al. [23] reported that TPs were associated with greater depression symptoms and higher rates of dyspareunia and constipation. Similarly in men, TPs were found in 75–88 % of men with chronic prostatitis/chronic pelvic pain syndrome [44]. Andersson et al. [45] also demonstrated that TP palpation in the PFMs and surrounding muscles reproduced the patient's symptomatology of pain in the penis, perineum, rectum, testicle, and groin. In fact, TP assessment is part of the UPOINT phenotyping system along with urinary symptoms, psychosocial dysfunction, organ-specific findings, infection and neurologic/systemic domains to classify urologic chronic pelvic pain [46].

11.3 Electromyography

EMG measurement is basically the recording of the electrical current travelling along the muscle fibers. During voluntary contraction, motor units, consisting of alpha-motoneurons and the muscle fibers they innervate [47], are recruited resulting in the liberation of acetylcholine (ACh) at the endplate [48]. The binding of ACh at the endplate leads to depolarization of the membrane, which then spreads as an action potential along the muscle fiber allowing liberation of calcium and, thus, the interaction of actin and myosin to produce muscle contraction. Surface EMG assessment will capture this electrical phenomenon and the number of motor units recruited and their frequency of discharge will influence the signal amplitude and, hence, the force output produced. In light of tone physiology, circulating current at rest can only be explained by electrogenic spasms (unintentional muscle contraction) and normal electrogenic contraction (resting activity in normally relaxed muscle, although controversial, and myotatic reflex during stretching). It should be emphasized, however, that neither the passive component (viscoelastic properties) nor the contracture (TP) is captured by EMG.

The literature shows conflicting results when comparing women with and without pelvic /vulvar pain. Some authors have found elevated resting activity [9, 49–51] while others have determined nonsignificant differences between women with pain and controls [7, 52, 53]. This highlights the hypothesis, that, in some women, the involvement of heightened PFM tone is not explained by an electrogenic cause. Various degrees of reliability were also found in the literature when assessing EMG amplitude during maximal contraction as well as resting activity. Such divergences strongly suggest that some confounding factors should be taken into account when interpreting EMG signals. Among other confounding variables, factors related to the detection itself, such as the contact between the electrodes and the mucosa, vaginal lubrication and the thickness of the vaginal tissue, can greatly affect the EMG signal. Moreover, the presence of crosstalk, i.e., contamination from neighboring muscles, should be considered when interpreting the force from the EMG [30]. Chapter 15 is dedicated to EMG and presents thorough discussion of the recommendations and limitations regarding EMG.

11.4 Ultrasound

Ultrasonography imaging is a technology that has aroused great interest in both clinical and research settings for assessing PFM morphology and function in men and women with various urological and gynecological conditions using transperineal and transabdominal approaches [11, 54–57]. It offers significant advantages over the other methodologies as no vaginal insertion is required and is therefore pain-free. Particularly in a context of chronic pelvic pain, this has the benefit of limiting the bias due to pain and also, presumably, the participant's fear of pain or penetration. It should be noted that a detailed discussion of the diagnosis of levator ani trauma post childbirth (i.e., avulsion) [58] and pelvic organ prolapse quantification [59] using transperineal ultrasound is beyond the scope of this chapter.

11.4.1 Transperineal Ultrasound for Assessing PFM Tone and Contractile Properties

Transperineal (also called translabial) ultrasound allows good visualization of the bladder neck, urethra, vagina, anorectal junction and levator ani muscle and measurements of organ movement in relation to a fixed bony landmark, the pubic symphysis, making it more reliable for comparison between subjects. This approach therefore allows quantification of morphological parameters at rest and during contraction. In the mid-sagittal plane, the assessment of organ positioning at rest is attributable in part to PFM tone while organ mobility during contraction is related to PFM contractile properties. In the axial plane using 3- and 4-dimensional (3D/4D) imaging, it can also provide visualization of the levator ani morphometry both at rest and during contraction. Assessment is performed with a curved array transducer (3–6 MHz; 5–8 MHz for 3D/4D), covered with a condom or glove (with conductive gel on the probe and on the condom) and firmly applied on the perineum in a mid-sagittal alignment. The patient is asked to empty her bladder prior to the test and

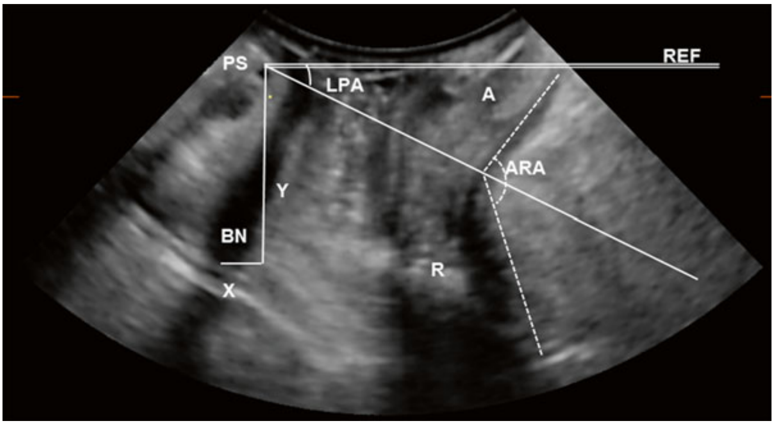

Fig. 11.1 Transperineal ultrasound—mid-sagittal plane. Identifying the anorectal angle (ARA, *dotted line*), the levator plate angle (LPA, *full line*), the bladder neck (BN), the pubis symphysis (PS), the anal canal (A), the rectal ampulla (R), the horizontal reference line (REF, *double line*), and the BN positioning relative to the *X*–*Y* axes

is usually evaluated in a recumbent position, although she can also be evaluated standing [60] or half-sitting [61]. Recent scientific literature abounds with parameters for evaluating PFMs at rest and during contraction.

In the 2D mid-sagittal plane (Fig. 11.1), the position and mobility of the bladder neck can be assessed. Dietz et al. [62] described analyzing this position using *x* and *y* axes relative to a horizontal line drawn from the inferoposterior margin of the pubis symphysis. Other authors propose using the whole pubis symphysis to trace the coordinate system aligning the *x*-axis with the central axis of the pubis symphysis [63, 64]. Both methods yield good test–retest and interrater reliability (coefficients *r* or ICC = 0.60–0.90) [60, 62, 65–67]. The cranioventral displacement of the bladder neck can also be calculated during contraction using the coordinate system [60, 62, 64, 67]. Similarly in men, the displacement of the bladder neck during a contraction demonstrated excellent test–retest reliability (ICC = 0.86–0.95) [61]. Furthermore, functional assessment of the bladder neck movement during coughing has been found useful in women with urinary incontinence in order to assess the reflex activity of the PFMs for stabilizing the bladder neck [68]. The ultrasound unit with a fast acquisition rate has the capacity to capture this rapid contraction. The anorectal angle, defined as the angle between the posterior wall of the rectal ampulla and the anal canal, can be calculated at rest [69]. During PFM contraction, the anorectal angle becomes more acute and moves cranially. This angle is influenced mainly by the puborectalis tone and contractile status [40]; it shows good reliability in both women and men (interrater reliability in men ICC = 0.57–0.70 [55]; test–retest in women 4.6–5.5 % of variation). With regard to the levator plate angle, this is measured between the horizontal reference line at the level of the pubis symphysis and the line from the inferoposterior margin of the symphysis pubis to the anorectal junction. It increases during contraction [60]. As discussed by Raizada et al. [40], the ascent (elevation) and descent of the pelvic floor, as evaluated by the levator plate angle, is hypothesized to be related to the tone and the contractile status of the pubococcygeus, ileococcygeus, and ischiococcygeus muscles. Good reliability was found in both women and men when assessing the angle at rest and its excursion during contraction (interrater reliability in men ICC = 0.90–0.93 [55]; interrater and test retest reliability in women ICC 0.46–0.64 [60, 66]). Instead of calculating an angle for quantifying the elevation of the levator, Stafford et al. [61] assessed the displacement of the anorectal junction using the coordinate system and showed excellent test–retest reliability in men (ICC = 0.83–0.93) for evaluating PFM contractile properties.

The development of 3D/4D ultrasound technology allows visualization of the levator ani muscle in an axial plane (Fig. 11.2) at rest and during contraction in order to assess hiatal biometry, muscle thickness, and muscle damage (i.e., avulsion injury). The measurements are made in the plane of minimal hiatal dimensions determined as the minimal distance between the

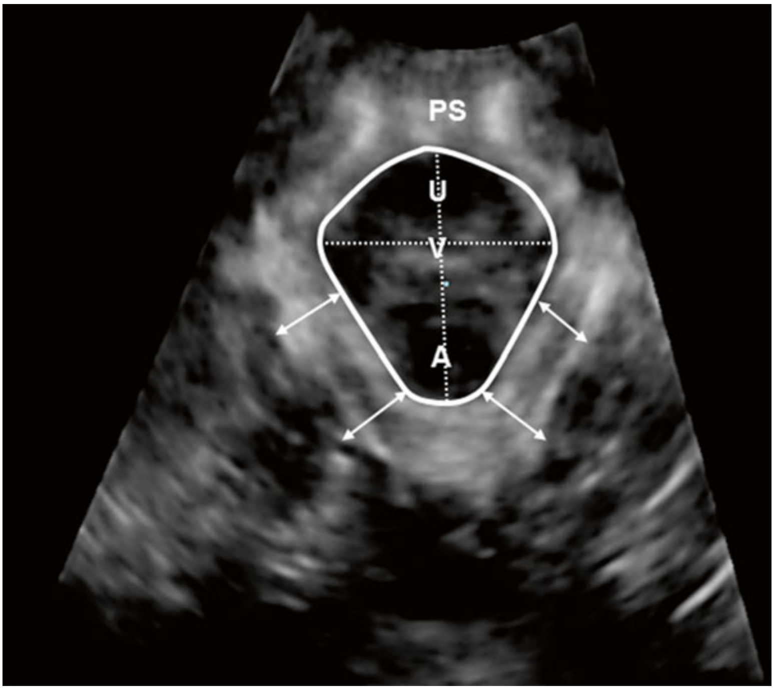

Fig. 11.2 Transperineal ultrasound—axial plane. Measurements taken in the axial plane of minimal hiatal dimensions. Identifying the pubis symphysis (PS), the urethral (U), the vagina (V), and the anal canal (A). Levator hiatus area (LH area) is marked with *lines*. The levator hiatus anteroposterior (AP) and left–right transverse (LR) diameters are drawn as a *dotted line* as well as thickness of pubovisceral muscle lateral to the vagina and rectum (*arrows*)

hyperechogenic posterior aspect of the symphysis pubis and the hyperechogenic back sling of the puborectalis muscle [71]. The levator hiatus area was delimited by the puborectalis muscle, symphysis pubis, and inferior pubic ramus in the axial plane [71]. Inside these borders, the anteroposterior distance corresponded to the levator hiatus anteroposterior diameter and the transverse distance measured at the widest part of the levator hiatus defined the levator hiatus left–right transverse diameter [60, 67, 71]. Measurements of the hiatus area and diameters at rest and their reduction during contraction showed good-to-excellent test–retest and interrater reliability (ICC = 0.61–0.96) [60, 66, 67, 71]. Levator ani thickness measurements can also be performed at rest with ICCs of 0.75–0.82 [60].

Moreover, supporting the validity of the measurements, transperineal ultrasound parameters have shown to be associated with different PFM assessment techniques and diagnostic tools [70, 72, 73]. For instance, dimensions of the hiatus, bladder neck, and levator displacement assessed with ultrasound have been associated with pressure perineometry ($r = 0.43$) [70, 72, 73], MRI measurement (ICC = 0.59–0.78) [74], vaginal palpation (modified Oxford grading system) ($r = 0.47–0.58$) [70, 75, 76], while the anorectal angle has been associated with evacuation difficulties and dyssynergia revealed with defecography findings [77]. In addition to the significant advantage of providing pain-free assessment, it has also been argued that Valsalva maneuver (i.e., straining) gives an insight into the extensibility of the PFMs under the force created by an increase in intra-abdominal pressure (IAP) and downward movement of the pelvic organs [71, 76]. However, when interpreting the findings obtained with ultrasound imaging, it is important to take into consideration that this is not a direct force measurement but rather an image showing the action of the muscle status. Hence, it is not a direct measure of muscle tone as it does not assess the resistance to stretching of the muscle.

11.4.2 Transabdominal Ultrasound for Assessing PFM Contractile Properties

A transabdominal approach has been described to evaluate movement of the posterior bladder wall during PFM contraction. The rationale for measuring the amount of bladder base movement as an indicator of PFM contractility/strength relies on the fact that the bladder is supported by PFMs and their fascia, and tensioning of the fascia after PFM contraction results in encroachment of the bladder wall. A convex probe with a frequency of around 3–6 MHz, applied on the lower abdomen, can be orientated to visualize the bladder base movement in either the sagittal or the transverse plane (Fig. 11.3). Bladder filling at a standardized volume is required to allow clear imaging of the base of the bladder. Test–retest reliability studies conducted mostly in asymptomatic women showed an excellent reliability for assessing bladder wall movement in the transverse (ICC = 0.81–0.92) and sagittal (ICC = 0.84–0.91) planes [78–80]. Excellent interrater reliability was also observed by Sherbrun et al. with ICCs of 0.86–0.87 and 0.86–0.87, respectively [78]. Similar findings for test–retest and interrater reliability have been reported in men with a history of prostate cancer [54] and chronic pelvic pain [81] when assessing bladder base movement during PFM contraction. Supporting the validity of transabdominal ultrasound, bladder base movement has been correlated to bladder neck displacement obtained with transperineal ultrasound ($r = 0.63$) [79] and vaginal squeeze pressure ($r = 0.72$) [80] in women. Significant correlation was also found with vaginal palpation (modified Oxford grading scheme) in men ($r = 0.57$) [54] and women ($r = 0.62$) [82]. Conversely, Sherburn et al. [78] found no correlation between the modified Oxford and bladder base movement in women (transverse $r = 0.21$ and sagittal $r = -0.13$).

Several limitations should be acknowledged when attempting to quantify muscle contraction using transabdominal ultrasound. As opposed to transperineal ultrasound, the bladder wall remains a surrogate of contraction as the musculature cannot be directly visualized with this approach. Khorasani et al. [81] pointed out that patients with chronic pelvic pain may have more pain with a full bladder and therefore more tension and less PFM mobility, which affects their bladder movement. Also, the measurements are made without reference to a bony landmark and the amount of bladder base displacement is only expressed relative to a moveable starting point. It

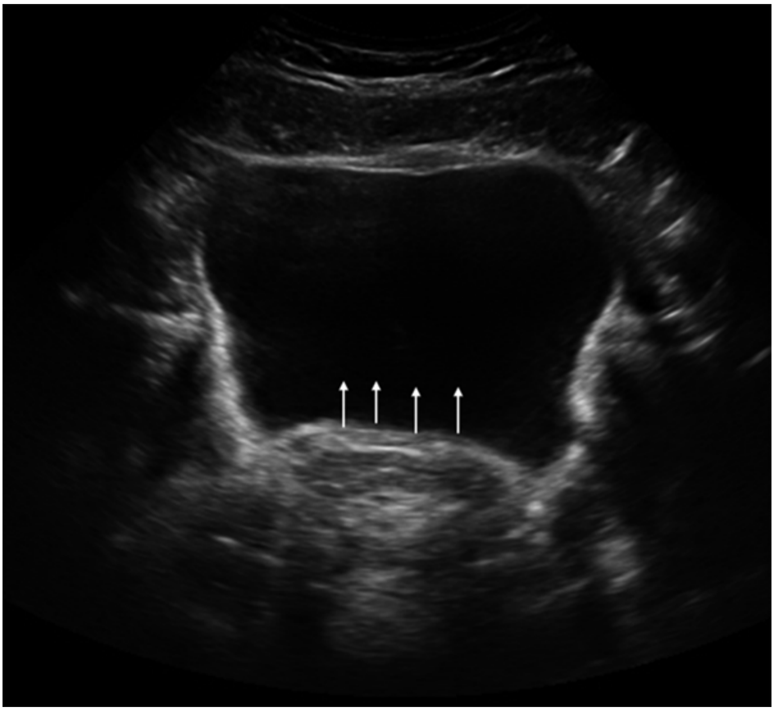

Fig. 11.3 Transabdominal ultrasound—transverse plane. Bladder base caudodorsal movement during PFM contraction

is therefore impossible to evaluate either the PFM tone or its contribution to the bladder movement. In other words, a patient with a hypertonic PFMs may exhibit a limited displacement of the bladder wall because the muscle is in an already contracted state. Moreover, abdominal muscle contraction and the presence of a prolapse can act as confounders. Thompson et al. [83] consequently suggested that transperineal approaches may be more reliable and suitable for inter-subject comparison.

11.4.3 Evidence in Women and Men with Heightened PFM Tone Using Ultrasound Imaging

A study comparing PFM morphology assessed with 3D/4D transperineal ultrasound in women with and without provoked vestibulodynia found that, at rest, women with PVD had a significantly larger levator plate angle, more acute anorectal angle, and smaller levator hiatal dimensions [11]. Taken together, this suggests higher PFM tone in women with provoked vestibulodynia. The fact that ultrasound assessment does not involve vaginal penetration and pain supports the hypothesis that the heightened PFN tone observed is not explained only by protective reactions. Moreover, as an indication of lower strength in the vestibulodynia group, less displacement of the bladder neck, less excursion of the levator plate and anorectal angles, and less levator hiatal narrowing were found compared to controls [11]. When evaluating men with urological chronic pelvic pain syndrome, similar ultrasound findings were reported suggesting heightened PFM tone in this population as well [55]. Using transabdominal ultrasound, Khorasani et al. [81] showed less bladder base movement during contraction, which may indicate lower strength. As discussed previously, this may be biased by an already elevated PFM tone limiting bladder base movement. Finally, transperineal ultrasound was found to be useful for diagnosing rectoanal dyssynergy as compared to defecography in men [84] and women [85] with symptoms of obstructed defecation. They found that rectoanal dyssynergy (paradoxical PFM contraction during straining) can be investigated by measuring anorectal angle during straining. In case of dyssynergia, the anorectal angle stayed small (acute) during straining instead of opening to allow evacuation.

11.5 Manometry

Manometry, also called perineometry or pressure measurement, is commonly used for evaluating PFM tone and contractile properties. It can also be utilized for anorectal investigation (see Chap. 12). It basically consists of a balloon—a vaginal pressure probe—connected to a manometer in order to measure the intravaginal pressure coming from the PFMs in millimeters of mercury (mmHg) or centimeters of water (cmH_2O) or other custom units, depending on the brand of manometers. It was in 1948 that Dr. Kegel [86] developed a perineometer to assess PFM strength in postpartum women with sexual dysfunctions. Since then, several types of pressure probes with different shapes and technical properties have been studied [87–90] and marketed under different brand names, for example, Camtech (Norway), Peritron (Australia), Miofeedback perina (Brazil), and Gymna (Belgium).

Vaginal resting pressure as a measure of PFM tone has been studied mainly in asymptomatic women and in women with incontinence. Using the Peritron device, good-to-excellent test–retest ($ICC = 0.74–0.77$) and interrater ($r = 0.78$) reliability have been demonstrated [34, 91]. However, resting pressure measurement in the upright position has resulted in poor reliability [38]. It should be pointed out that there are no clear recommendations as to whether the device should be calibrated to zero prior to insertion into the vaginal cavity nor how much the probe should be inflated prior to measurement. The latter would influence the probe size and, consequently, the muscle length and amount of resting pressure recorded. With regard to muscle physiology, intravaginal resting pressure will be influenced by a combination of the active and passive tone components.

Regarding contractile properties, maximal pressure during PFM voluntary contraction has shown excellent test–retest (ICC = 0.88–0.96) and interrater reliability ($r = 0.88$) [34, 38, 91–94]. These studies were done in a pain-free sample using the Peritron device. It is suggested that the device be recalibrated to zero just before every effort. Maximal strength could be reliably evaluated during a 3-, 5-, or 10-s contraction by considering one trial or the mean of three trials [34, 38, 91–94]. Regarding endurance measurement, Frawley et al. [34] found that endurance assessed during 20 repeated contractions was not reliable. Contrarily, Rahmani et al. [93] demonstrated excellent reliability when assessing endurance during a sustained 60 % maximal contraction (ICC = 0.83).

In support of the validity of manometry, maximal pressure measurement has been found to be correlated with vaginal palpation (modified Oxford scale ($r = 0.70–0.81$) [33, 95, 96] and Brink's scale ($r = 0.68–0.71$) [91, 92]), transabdominal ultrasound (bladder base movement ($r = 0.72–0.81$) [80, 95]) as well as transperineal ultrasound (bladder neck movement ($r = 0.43$) [70] and muscle thickness ($r = 0.49–0.70$)). Resting pressure was correlated with the levator hiatus area assessed by transperineal ultrasound ($r = -0.46$) [97]. However, it is generally recognized that increases in IAP, occurring if a patient co-contracts the abdominal muscles (rectus abdominis), or strain instead of contracting the PFMs can bias pressure measurements. Bo and Sherburn formulated recommendations to ensure the validity of the measurement [98]: (1) performing vaginal palpation before using the perineometer to make sure the patient is able to correctly contract her PFMs; (2) observing the cranial movement of the vaginal probe during measurement of the muscle contraction and (3) not considering the contractions associated with the Valsalva maneuver or retroversion of the hip [99, 100]. Following the last point, Bo and Constantinou [101] wrote a comment explaining that pressure should not be used to assess the reflex contraction of the PFM during coughing. They argue that pressure measurement is a summation of signals including PFM and IAP caused by the cough itself and that it is unlikely that the PFM reflex can be assessed in isolation. Considering these recommendations, the use of perineometry poses a problem when a patient has a really low PFM strength, because no inward movement of the probe is possible in this case. Furthermore, the size of the probe and the brand of the device have also been shown to influence the measurement [102, 103]. Barbosa et al. [103] compared the Peritron with two Brazilian devices and Bo et al. [102] compared the Peritron to the Camtech. Both studies conclude that measurements of vaginal squeeze pressure differ depending on the probe used. Despite these studies focused on maximal squeeze pressure, the results can be transposed to PFM tone assessment according to findings obtained with other tools [104, 105]. Different devices should therefore not be used interchangeably in clinical settings and results using different probes should not be compared or combined in systematic reviews or meta-analyses. The placement of the probe is another factor reported to be important. It was recommended to position the probe at the level of the PFMs that corresponds to the high-pressure zone inside the vagina [106, 107]. In sum, none of these studies on psychometric properties were undertaken in women with an overactive pelvic floor. Further investigation should be conducted in this population.

11.5.1 Evidence in Women with Heightened PFM Tone Using Manometry

Most of the studies so far have used manometry for investigating PFM dysfunctions in women with and without urogynecologic conditions such as incontinence and pelvic organ prolapse. There is thus a paucity of studies documenting its utilization in women with pelvic pain and an overactive pelvic floor. Rogalski et al. [108] demonstrated a significant reduction in resting vaginal pressure in women with a high-tone pelvic floor after intravaginal diazepam suppositories. In conference proceedings, Naess et al. [53] showed that women with provoked vestibulodynia had significantly higher vaginal resting pressure compared to controls. In line with the hypothesis that elevated PFM tone may not always be explained by an electrogenic cause, these authors' results were not corroborated by EMG, as they found a nonsignificant difference in resting activity between the two groups. Furthermore, they observed a reduction in PFM resting pressure after a maximal contraction in women with provoked vestibulodynia indicating that contracting the PFMs can be used as a muscle relaxation technique.

11.6 Dynamometry

Several versions of intravaginal dynamometers have been developed in the last two decades for quantifying PFM tone and contractile properties. Another device, a myotonometer, has also been used for evaluating PFM tone by applying pressure externally on the perineum. Moreover, PFM tenderness and TPs can also be evaluated objectively with dynamometric devices (e.g., palpometer) in order to evaluate the pressure pain threshold.

11.6.1 Intravaginal Dynamometers

In the last two decades, over 11 intravaginal dynamometers have been developed to assess PFM properties. The *tonimetric device* also known as the "pince tonimétrique" developed by M. Caufriez was the first dynamometer to measure the PFM function [109, 110]. This dynamometer consists of two branches that can be opened by pressing on two handles in an angular excursion to increase the vaginal aperture. Although initially designed to assess PFM tone following an anteroposterior vector (i.e., at 12 and 6 o'clock), it can also measure PFM contractile properties. *Row's dynamometer* was described in a brief conference abstract. It consists of a probe with a movable rigid-window section against which the PFMs press during a contraction [111]. However, the latter were not studied for their psychometric properties and not used in other scientific works.

Michigan's dynamometer, used in clinical trials in women with incontinence and prolapse, and described in a patent document [112–115], is composed of two speculum branches equipped with strain gauges and affixed together in order to measure PFM tone and contractile properties at a predetermined static vaginal aperture. Test–retest reliability was only studied for strength measurement and an excellent reliability was found (ICC = 0.83) [116].

The *Montreal dynamometer* [117], designed to evaluate anteroposterior resting and contractile forces, comprises two aluminum branches: the upper one is fixed while the lower one, equipped with gauges, can be moved downward to increase vaginal aperture. The speculum is mounted on a supporting base so that the evaluator cannot bias the device by moving the unit, and the insertion of the speculum can follow the natural angle of the vagina [104, 118]. Several improvements were made to the dynamometer since its initial design in order to assess PFM tone, such as: (1) the mechanism that widens the vaginal opening was modified to create a smoother opening and a numerical linear-position transducer was incorporated to provide real-time measurement of the distance between both branches during a dynamic stretch [104, 118]; and (2) the size of the branches was reduced to that of a pediatric speculum to enable the assessment of women with vulvovaginal pain [10]. The speculum was designed to assess PFM tone more extensively, especially passive properties, by transposing to the pelvic floor a methodology used in the muscles of the limbs. This method consists in passively and slowly stretching the muscle while monitoring EMG activity to detect any electrogenic contributions [119, 120]. The EMG has to remain absent or negligible throughout the test, which can be defined by 1 % of maximal voluntary contraction or increase in EMG higher than two-standard deviation (SD), in order to assess only the passive properties of the muscle [2, 121]. Using four pairs of EMG electrodes affixed to the lower branch to monitor EMG, the following methodology was proposed to evaluate the PFM tone under four conditions [104, 118]: (1) PFM forces were recorded with the speculum closed at its minimal opening; (2) PMF forces were recorded at the maximal vaginal aperture which corresponds to the maximal muscle length; the maximal stretching amplitude was determined by either the participant's tolerance limit or an increase in EMG activity; (3) To assess PFM passive properties during a dynamic stretch, the PFMs and surrounding tissues were stretched during five lengthening and shortening cycles conducted at constant speed; passive forces and passive elastic stiffness (PES) ($\Delta F/\Delta$aperture – muscle length) were calculated at different vaginal apertures. The muscle that exhibits greater passive resistance (greater force recording) and higher PES is considered "stiffer." The relationship obtained between the muscle length and the passive forces recorded clearly demonstrated that a larger aperture results in higher passive forces in asymptomatic pain-free women. The area between the lengthening and the shortening curve (i.e., the loss of energy associated with lengthening of viscoelastic tissues), called hysteresis, was also computed; (4) The percentage of passive-resistance loss after 1 min of sustained stretching was calculated to evaluate a skeletal muscle behavior known as "stress-relaxation" (i.e., loss of resistance over time with a sustained stretch) can be measured by computing the percentage loss in passive resistance following the application of a steady stretch over a prolonged period [119]. This methodology showed good-to-excellent test reliability in women with SUI with ICCs ranging from 0.66 to 0.88 [118]. Only passive forces at minimal aperture showed fair to good reliability with ICC of 0.51 [118]. Furthermore, contractile properties such as strength, speed of contraction, and muscle coordination as well as muscle endurance can be evaluated with the Montreal dynamometer. Maximal strength, calculated as a maximal force obtained during a 10-s contraction minus the baseline resting force, showed good-to-excellent test–retest reliability in postpartum women with ICC of 0.71, 0.88, and 0.76 for vaginal apertures of 19, 24, and 29 mm, respectively. As explained previously, Dumoulin et al. [122] confirmed that muscle length influences the force output, i.e., higher contractile forces are produced at wider apertures. For the speed measurements, the women were instructed to contract maximally and relax as fast as possible for 15 s. The speed of contraction was quantified by the rate of force development of the first contraction and the number of contractions performed during the 15-s period. Excellent test–retest reliability were found with ICCs 0.79–0.92 [118]. In the endurance test, the women were asked to maintain a maximal contraction for 90 s and the normalized area under the force curve was computed: (area under the curve/maximal strength) × 100 (ICC = 0.81). Various studies have been conducted to support the validity of dynamometric measurements. The maximal strength recorded with the dynamometer was correlated to vaginal palpation (modified Oxford scale, $r = 0.727$) [123]. Moreover, dynamometric measurements have been proven to be minimally influenced by increases in IAP [124]. Furthermore, good sensitivity to detect changes following treatment was also demonstrated [125].

Regarding the dynamometer developed by *Verelst & Leivseth* [105, 126, 127], it is composed of two branches to assess the PFM tone and contractile forces in a laterolateral position (i.e., transverse) rather than an anteroposterior force vector. Both branches can be opened to allow measurement from 30 to 50 mm of transverse opening. They evaluated the test–retest reliability of strength measurements using a coefficient of variability in women without any urogynecological conditions [105]. They obtained coefficients ranging from 11 to 22 %, which indicates good reliability. Although the assessment was done in the transverse direction, the same researchers also observed that the vaginal aperture influences the PFM strength assessment [105]. It should be pointed out that the size of the device may be a problem for the assessment of PFMs in women with pain.

Constantinou et al. [128, 129] developed a probe with four sensors, each mounted on a leaf spring that can be expanded once inserted to contact the vaginal wall and then retracted to a smaller diameter for probe removal. This configuration allows the assessment of spatial distribution of passive and contractile forces for each quadrant (anterior, posterior, left, and right). A positioning system was added to the probe handle in order to track the orientation/angulation of the probe during PFM assessment [130]. This device has proven useful for discriminating between women with and without urinary incontinence [130, 131]. Likewise, *Saleme* et al. [132] designed a probe that similarly aimed to evaluate the spatial distribution of the PFM forces with the only exception that the sensors are not mounted on extractible leaf springs but are rather positioned on the probe. A study evaluating the positioning of this device using nuclear magnetic resonance imaging confirmed that the device's dimensions and sensor configuration were correctly positioned at the level of muscle mass to measure PFM strength, thereby collaborating validity. The reliability of Constantinou's and Saleme's devices has not been studied and their acceptability in women with gynecological pain also needs to be evaluated.

Three other speculum prototypes (from Nunes, Parezanovic-Ilic, and Romero-Culleres) were developed using the two branches of a conventional gynecological speculum equipped with strain gauges [133–135]. The *Nunes speculum* rests on a support system that can be turned to evaluate the PFM strength in the anteroposterior or transverse direction. The strength measurements were taken at different vaginal apertures which were individually adjusted to reach 4.9 N of passive forces. Evaluation of the test–retest reliability of strength measured in the anteroposterior and transverse directions reveals ICCs of 0.71–0.91 and 0.46–0.76, respectively [135]. In regards to the *Parezanovic-Ilic's speculum*, the information available is somewhat limited, since it was given in an article written in Serbian. The *Romero-Culleres speculum* was presented recently in a conference abstract [133]. Excellent interrater reliability of strength measurement was obtained in incontinent women with an ICC of 0.93 and the measurements were also found to be related to digital palpation (modified Oxford grading system).

The *Elastometer* developed by Kruger et al. [136, 137] was designed to assess the PFM tone in order to investigate its role in predicting delivery-related trauma. The two aluminum branches covered by removable plastic tips are introduced in the vagina and positioned to produce a transverse stretch with the help of a motor incorporated into the speculum. This enables the evaluator to apply a controlled stretch, at a constant speed, to the PFM tone in a transverse direction. The Elastometer reliability study focused on an assessment of PFM tone, as this was the purpose for which it was specifically designed, in asymptomatic women [136, 137]. Data acquisition was automated with the device opening in 20 stepwise increments from 30 to 50 mm over a 60-s period. Test–retest reliability was found to be excellent with ICCs of 0.86–0.92.

Overall, the intravaginal PFM dynamometers differ in terms of size and shape, the force vector recorded anteroposterior, laterolateral, or multidirectional forces and other technical issues. One main advantage is that they provide direct force assessment and most of them have been studied for their reliability. With the exception of the Montreal dynamometer, they evaluate PFM tone as the summative contribution of the active and passive components. Indeed, a methodology combining dynamometry and EMG was proposed to evaluate PFM passive properties while the activity of the muscle remains negligible. The main limitation associated with PFM dynamometers is their lack of accessibility because these devices are mostly used by their designers and not commercially available. Moreover, only the Montreal dynamometer was adapted and used in a sample of patients with pain and heightened pelvic floor conditions.

11.6.2 Myotonometer

A myotonometer (the MyotonPro™) is an instrument that has been used in skeletal muscle of the limbs to assess muscle tone [138–140]. This technology has been used recently for PFM assessment by applying pressures externally on the perineum [141, 142]. The device consists of a hand-held unit that is applied on the muscle at a predetermined level of pressure (preload). The device exerts mechanical impulses followed by release inducing damped oscillation on the muscle at rest. Several parameters can be extracted from the oscillation curve, such as muscle stiffness which corresponds to the variation of forces divided by displacement of the tissue [138–140]. Interrater reliability was found to be good to excellent (ICC = 0.70–0.86) for assessing perineal muscle stiffness in women with and without vulvodynia [141, 142]. Although it is a new instrument in the field of pelvic pain and it has not yet been published in peer-reviewed journals, its utilization for assessing global PFM tone (i.e., summative contribution of active and passive components) is promising.

11.6.3 Pelvic Floor Tenderness and Pressure Pain Threshold

As discussed above, digital palpation is used to assess TP and muscle tenderness. In an attempt to provide a more objective assessment, Tu et al. [143] developed a device, a palpometer, to investigate pelvic floor tenderness, also called pressure pain threshold or mechanosensitivity. It consists of a force-sensing resistor attached to the index of the evaluator, covered with an examination glove, in order to evaluate the intensity of pressure required to elicit pain in various pelvic floor sites (pubococcygeus, puborectalis, obturator, ischial spine). Good-to-excellent test–retest reliability was found with a coefficient ranging from 0.61 to 0.84 [143]. Although it is not a PFM tone measurement, it provides relevant information about muscle pain and TPs which are closely linked to PFM heightened tone.

11.6.4 Evidence in Women with Heightened PFM Tone Using Dynamometry

The Montreal dynamometer was the only dynamometer used to investigate and compare the PFM passive properties and contractile properties in women with provoked vestibulodynia and controls [10, 144]. Higher PFM passive resistance at minimal aperture, higher stiffness at minimal and 15 mm aperture as well as lower hysteresis was found in women with provoked vestibulodynia [10, 144]. However, it should be underlined that women with provoked vestibulodynia tolerated lower vaginal aperture and some of them had more difficulty maintaining a low level of EMG activity. When excluding women with EMG activation during stretching, the same results were observed, suggesting the relevance of the passive/viscoelastic components of muscle tone to the findings of PFM impairments in women with PVD (unpublished data). Furthermore, women with vestibulodynia also showed lower maximal PFM strength, endurance, and speed of contraction, and achieved a lower number of contractions in 15 s. This suggests that contractile properties are also involved in provoked vestibulodynia pathophysiology [10, 144].

Using the myotonometer, Davidson et al. [141, 142] showed that women with vulvodynia had higher PFM tone (stiffness) compared to asymptomatic controls. With regard to pelvic floor tenderness, enhanced PFM pressure-pain sensitivity measured by palpometer during examination was also found in women with chronic pelvic pain for measurements compared to controls [9, 145]. Fenton et al. [146] even demonstrated that pressure pain threshold assessment can be useful for categorizing women with chronic pelvic pain into two groups (high sensitivity and low sensitivity according to their pain threshold). Such phenotyping should be further studied to determine if it influences the response to treatment. Similarly, in men with urological chronic pelvic pain syndrome, lower thresholds were found on the perineum area compared to controls [147].

11.7 Other Physical Examination Aspects

In addition to PFM tone and contractile properties, other physical aspects should be taken into consideration in conditions related to overactive pelvic floor. Connective tissue abnormalities (also termed “subcutaneous panniculosis”) is reported to be associated with the presence of TP in underlying muscles and refers to a thickening of the subcutaneous tissues with an increased consistency and resistance to skin rolling [25]. Fitzgerald and Kotarinos [25] explained that connective tissue abnormalities are frequent in women with overactive pelvic floor and they identified commonly affected regions on the abdominal wall, thighs, low back, buttocks, and perineum. Connective tissue assessment as well as mobilization techniques warrant further empirical investigation into psychometric properties and treatment effectiveness. The pudendal nerve may also be involved in conditions related to an overactive pelvic through adverse neural tension (local factors interfering with nerve mobility during body movement), neuralgia, compression/entrapment, and neuropathy [25]. Likewise, a heightened PFM tone may also occur in response to inadequate posture, hip and sacroiliac joint dysfunctions [148]. Although these physical aspects were not in the scope of this chapter, a broader neurological and musculoskeletal assessment is mandatory in women with overactive pelvic floor.

11.8 Conclusion

Several assessment tools are available for assessing heightened PFM tone. Each instrument possesses its own advantages and limitations and evaluates different components of muscle tone. There is no one method capable of identifying the contributions from all the active and passive components of muscle tone. There is consequently neither published nor clinical evidence to suggest the existence of a single tool to comprehensively assess the PFM tone and contractile properties. A combination of tools is probably the most suitable approach to gaining a better understanding of pathophysiology. The available evidence in women and men with conditions related to an overactive pelvic floor suggests an elevated global PFM tone (measured by ultrasound, dynamometry, and manometry) TPs (measured by palpation and palpometer), increased viscoelastic properties (dynamometer and EMG), and, for some patients, elevated tone explained by electrogenic causes (evaluated by EMG). Empirical findings also indicate that the assessment of PFM should not be limited to tone since the contractile properties (strength, speed of contraction, control, and endurance) were also shown to be altered. It is still unclear, however, whether these dysfunctions result from pain inhibition, motor control deficits, or muscle weakness. Future research should be oriented toward further investigating the underlying mechanisms of elevated PFM tone, and studying the specific effects of physiotherapeutic interventions in terms of changes in PFM tone in women and men with overactive pelvic floor.

11.9 Appendix

Throughout this chapter, reliability and validity coefficients were interpreted following accepted standards. Reliability assessed with ICC was characterized as poor (ICC < 0.4), fair to good (ICC 0.40–0.59), good (ICC 0.60–0.74), or excellent (ICC >0.75) [149]. Kappa coefficients were described as poor (<0.21), fair (0.21–0.40), moderate (0.41–0.60), good (0.61–0.80), and very good (>0.80) [150]. Finally, correlation coefficients were interpreted as little or no relation (0.25), fair (0.25–0.50), moderate to good (0.50–0.75) and good to excellent (>0.75) [151].

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