Neurourology and Urodynamics

Reliability and Differentiation of Pelvic Floor Muscle Electromyography Measurements in Healthy Volunteers Using a New Device: The Multiple Array Probe Leiden (MAPLe)

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Aims: A new multiple electrode probe, the Multiple Array Probe Leiden (MAPLe), has been developed for biofeedback registration of the individual pelvic floor musculature (PFM). The aim was to determine the reliability and differentiation of electromyography (EMG) signals measured with the MAPLe in healthy volunteers. **Methods:** Two hundred twenty nine healthy volunteers not seeking treatment or using medication for symptoms of prolapse, lower urinary tract, bowel, pain, and/or sexual function related to pelvic floor dysfunction were qualified to participate. Subjects were asked to perform five tasks: rest, maximum voluntary contractions, endurance, cough, and valsalva. Mean EMG values per electrode were registered. Test–retest reliability was assessed using linear mixed model with random subject effects. One-way ANOVA tests were performed to detect differences between groups. **Results:** Magnetic resonance imaging (MRI) showed that each of the electrodes could be related nearest to the individual muscles. For test-retest, the intraclass correlation ranged from 0.53 to 0.91. The MAPLe showed significant differences in average EMG values between men and women, and between nulliparous and parous, pre- and prostmenpausal women. Significant differences were seen between the left and right sides of the pelvic floor. In addition, the activity nearest to the individual pelvic floor muscles (external anal sphincter (EAS), puborectalis muscle, bulbospongiosus, ischiocavernosus and the pubococcygeus muscle) could be determined. **Conclusions:** The MAPLe is a reliable instrument measuring the EMG signals of the different sides and levels nearest to the pelvic floor musculature and is capable to differentiate between men and women, nulliparous, parous, pre- and postmenopausal. The findings of this study have implications for the diagnosis and treatment of pelvic floor dysfunction in the future. *Neurourol. Urodynam.*

Key words: biofeedback; electrostimulation; medical device; pelvic floor

INTRODUCTION

The pelvic floor comprises several layers, including the pelvic diaphragm (levator ani and coccygeus muscles) and the urogenital diaphragm. Each diaphragm has its own 3D shape and position with regard to the internal pelvic organs. The urogenital diaphragm consists of a deep layer, the perineal membrane, and a superficial layer, consisting of the bulbospongiosus muscle and the ischiocavernosus muscle.[1–5] The levator ani muscle is made up of the iliococcygeus, pubococcygeus, and puborectalis muscles. Together with the urethral and anal sphincters, these muscles play an important role in preventing complaints of micturition, defecation, sexual dysfunction, prolapse, and/or pelvic floor pain.[4,6–9] The development of one of these complaints is referred to as pelvic floor dysfunction (PFD). Contraction of the pelvic floor is thought to involve contraction of all, or some of the muscle groups.[1,9,10]

Pelvic floor muscle (PFM) function can be qualitatively defined by grading both the tone at rest and the strength of a voluntary or reflex contraction as strong, normal, weak or absent, or by using a validated grading symptom scale. By measuring PFM based on signs and symptoms, the following conditions can be determined: normal pelvic floor muscles, overactive pelvic floor muscles, underactive pelvic floor muscles, and non-functioning pelvic floor muscles.[8,11]

A voluntary PFM contraction is described as a squeeze around the pelvic opening and an inward lift.[12] Evaluation of such a contraction involves assessment of the ability to elevate the pelvic floor, as well as assessment of muscle strength, endurance, and coordination.[1] Various clinical methods, each with its own advantages and disadvantages, have been used for the assessment of PFM contraction or function. These methods include observation, palpation,[13,14] electromyography (EMG),[15,16] ultrasound,[17–19] magnetic resonance imaging (MRI),[19] manometers[20–22] and dynamometers.[1,14,23,24]

In the 1950s, Kegel first used a device to evaluate PFM contraction. This device, called a perineometer, was a vaginal

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Conflict of interest: Petra J.Voorham- van der Zalm, Theo J.Ouwerkerk and Rob C.M.Pelger are the inventors of the MAPLe.
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probe connected to a manometer and measured vaginal air pressure.[12] However, his studies presented no data about the sensitivity, reliability or validity of this method.[1] Nowadays, surface EMG with electrodes embedded on vaginal and anal probes is more widely used to assess PFM neuromuscular function and to increase our understanding of pelvic floor function.[1,21,22,25–29]

Many EMG devices are used to record intravaginal and intra-anal biofeedback during the treatment of PFD. The devices come in various shapes and sizes,[14,23,24,30,31] and most comprise large plates or rings. However, these devices have all been developed empirically and are not specifically designed with the pelvic floor anatomy in mind. Consequently, the electrode covers multiple pelvic floor muscles and registers other muscles in the proximity, such as the abdominal muscles.[14] Thus, current devices are not optimized for biofeedback registration of the pelvic floor musculature since they are not capable of registering the activity of a single component of the PFM.

In addition, there is no scientifically validated standard for normal pelvic floor function measured with these devices.[1,31]

To address these issues, a new multiple electrode probe, the Multiple Array Probe Leiden (MAPLe), has been developed. The MAPLe is designed to optimally register EMG signals from the different sides and layers of the PFM.

We hypothesized that each individual electrode of the MAPLe would be located nearest to the different (parts of) the muscles of the PFM.

The aims of this study were to determine the reliability of the EMG signals measured with the MAPLe, to determine the differentiation of the EMG values nearest to the different muscles of the pelvic floor and to determine the differentiation between the different groups of volunteers.

MATERIALS AND METHODS

Healthy volunteers not seeking treatment and not using medication for symptoms of pelvic organ prolapse (POP), lower urinary tract symptoms, bowel symptoms, pain, and/or sexual dysfunction related to PFD were qualified to participate. The volunteers, aged ≥18–75 years, were divided into five groups: males; nulliparous, premenopausal females; parous, premenopausal females; nulliparous, postmenopausal females; parous, postmenopausal females.

Feasibility analysis predicted that a sample size of 30 participants per group would be adequate to detect differences in EMG values between the groups.[22] Healthy volunteers were invited to participate by oral and written advertisement from January 2010 until June 2011.Volunteers were included by questionnaire, by email, or by telephone. Volunteers were excluded if they were using any medication for complaints of sexual function, micturition, and/or defecation, if they had a diagnosis of diabetes or neurological conditions involving pelvic floor function, if they had a history of gynecological or rectal surgery, sexual abuse, or severe psychiatric impairments, if they were pregnant or had recently given birth or if they did not understand Dutch well enough to precisely execute the tasks.

The Medical Ethical Committee approved this study and all volunteers provided written informed consent.

Instrumentation

The MAPLe is a probe with a matrix of 24 electrodes to measure EMG signals from the different sides and layers of the pelvic floor musculature (PFM; Fig. 1). The MAPLe can be used for vaginal and for anal measurements. The probe has a diameter of 15 mm, and the electrodes are situated at six levels, 10 mm apart, on four different sides of the probe (front, back, left, and right). For this study, several identical probes were used.

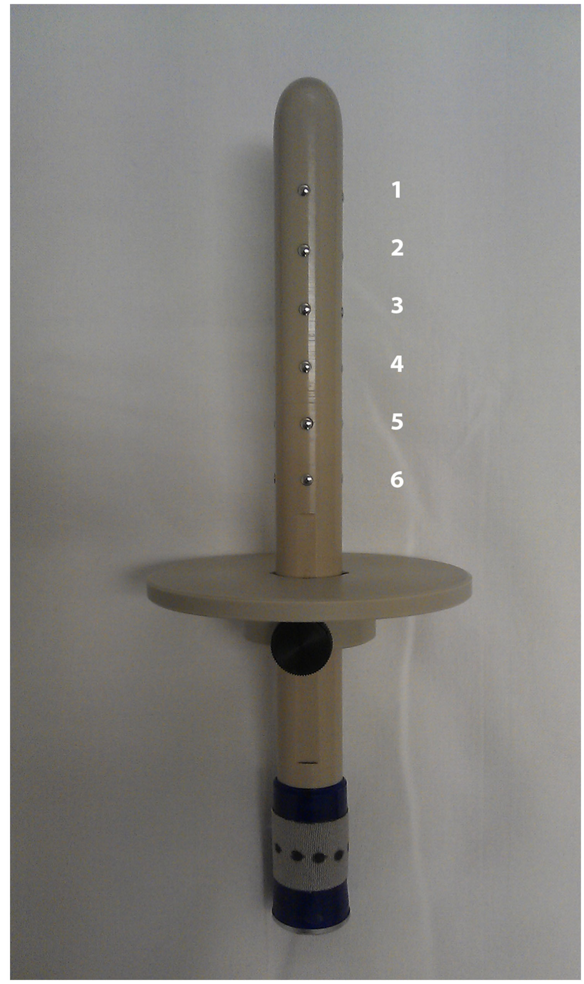

Fig. 1. MAPLe.

Women were first measured vaginally in the supine position with the knees bent and legs slightly apart and then anally in the side position with knees bent. Men were measured anally in the side position.

An experienced pelvic floor physiotherapist confirmed correct placement and orientation of the probe. Correct placement requires the most caudal electrodes to be located at the level of the external anal sphincter (EAS) or hymen. Correct orientation requires the different sides to be correctly aligned with the front, back, left, and right side of the volunteer. The probe has a removable shield with a mark to aid the therapist in maintaining a standardized insertion depth and orientation during the tasks. For vaginal measurements, this shield was placed facing the perineum and, for anal measurements, it was inserted facing the gluteus muscle. A reference electrode was placed on the left spina iliaca anterior superior.

Placement of the electrodes with respect to the anatomy of the PFM was checked by MRI (1,5T2) and correct PFM contraction was checked using 2D and 3D ultrasound (BK Medical®) in a random group of volunteers. Additionally, surface electrodes registered the activity of abdominal, gluteal, and adductor muscles. After insertion, the therapist held the probe in place during the measurements by supporting it manually.

After placement of the probe, subjects were asked to perform five consecutive tasks, each separated by a 1-min rest: 1 minute rest, 10 maximum voluntary contractions (MVC) held for <3 sec, three maximal endurance contractions of 30 sec, three maximal effort coughs, and three valsalva manoeuvres. For the MVC task, the volunteers were instructed to strain the pelvic floor muscles as if they have to keep in urine or flatus, and, for the endurance task, they were asked to hold this contraction for 30 sec. For the valsalva manoeuvre volunteers were ask to push.

Data Collection and Processing

MRI scans were performed in the sagittal, coronal, and transverse plane, centered on the MAPLe. In the analysis the position of the specific muscles of the PFM were located, compared, and matched to the specific electrode levels. The electrode levels were defined as the planes through the electrodes at the left, right, top, and bottom at one specific level (six in total).

Unipolar raw EMG signals were acquired with a Porti32, a 32-channel EMG acquisition device (TMSi®) at a sample rate of 2,048 Hz. For each electrode, the signals were prefiltered with a third order high-pass Butterworth filter with a 9–11 Hz cut-off frequency. For each signal, the root mean square was calculated using a window of 205 samples (0.1 sec).

For rest, mean EMG values were calculated for each electrode nearest to the specific muscles of the PFM. For the MVC, average EMG values were calculated for each electrode nearest to the specific muscles of the PFM by calculating an average over all repetitions. In this calculation, the highest and lowest MVC values were omitted. For the endurance, average EMG values were calculated over the three repetitions. Data processing and calculations were performed using Matlab® R2009b.

Data analysis was performed using SPSS 18. Test–retest reliability was assessed in a random group of volunteers using linear mixed models with random subject effects. Intraclass correlations (ICCs) from these models are reported. One-way ANOVA tests were performed to detect differences between groups. For post hoc pair-wise testing, further Bonferroni adjustment was applied.

RESULTS

In total, 229 healthy volunteers were assessed. The volunteers were divided into five groups: males (N = 61); nulliparous, premenopausal females (N = 86); parous, premenopausal females (N = 37); nulliparous, postmenopausal females (N = 5); parous, postmenopausal females (N = 40). Table I shows the demographic data by group.

TABLE I. Demographic Data by Group

	Age (interval)	Gravida (interval)	Para (interval)
Men (N = 61)	41 (19–70)	NA	NA
Nulli pre (N = 86)	24 (18–49)	0	NA
Parous pre (N = 37)	44 (32–56)	2.38 (1–5)	2.24 (1–4)
Nulli post (N = 5)	54 (50–65)	0.6 (0–3)	NA
Parous post (N = 40)	58 (51–72)	2.50 (1–6)	2.3 (1–5)

NA, not applicable.

During the research setting, we excluded five volunteers. Three of these volunteers suffered from urinary incontinence during coughing, one did not understand the instructions, and finally, during the intake, one reported a history of sexual abuse.

The group of nulliparous postmenopausal women was excluded from the final analysis because the sample size (N = 5) did not meet the minimum size for a reliable analysis.

We included healthy volunteers with no complaints of POP. During inspection we did not see POP > I.

Placement and Positioning

Location of the electrodes with respect to the different muscles was checked with static and dynamic MRI, vaginally (N = 5) and anally (N = 9) in a random group of volunteers.

We hypothesized that the different levels on the left, right, back, and front side of the probe should be located nearest to the different muscles of the pelvic floor.

In the analysis the position of the specific muscles of the PFM were located, compared and matched to the specific electrode levels. The electrode levels were defined as the planes through the electrodes at the left, right, top, and bottom at one specific level (six in total). In Figure 2 the levels are indicated. The most caudal electrode level was located at the bulbospongiosus and ischiocavernosus or the EAS. In the sagittal and coronal images the electrode planes were represented as straight lines, perpendicular to the outer surface of the probe and through the left and right or top and bottom electrode at the same level.

Upon anal insertion in all groups, electrodes 1 and 2 on the left and right side of the probe were located nearest to the pubococcygeus muscle. Electrodes 3 and 4 on the left and right side of the probe were located nearest to the puborectalis muscle, and electrodes 5 and 6 on the left and right side of the probe and at the front and back were located nearest to the EAS in both men and women (Fig. 2a). In terms of the front face of the probe, electrodes 1 and 2 were located nearest to the bladder (men and women) and vesicular glands (men), electrodes 3 and 4 were situated nearest to the urethra (men and women) and prostate (men), while electrodes 5 and 6 were situated nearest to the urogenital diaphragm in men (Fig. 2b).

Upon vaginal insertion, electrodes 1 and 2 on the left and right side of the probe were located near the pubococcygeus muscle. Electrodes 3 and 4 on the left and right side of the probe were located near the puborectalis muscle, and electrodes 5 and 6 on the left and right side of the probe were located near the bulbospongiosus muscle and the ischiocavernosus muscle (Fig. 2c). In terms of the front of the probe, electrodes 1 and 2 were located nearest to the bladder, electrodes 3 and 4 were located nearest to the urethra, and electrodes 5 and 6 were nearest to the urogenital diaphragm (Fig. 2d).

When vaginal placement of the probe in parous postmenopausal women was checked in one woman by MRI, we noticed that the electrodes were located nearest to the same PFM, however it showed more tissue between the electrodes and the PFM. The location of the muscles in the specific electrode planes did however not differ from the other volunteers.

Dynamic MRI and ultrasound during MVC revealed a displacement of the PFM, the coccyx and the anorectal angle (ARA) in a ventral direction towards the pubic symphysis. The electrodes did not move with respect to the vaginal or anal wall, the probe was not tilted inwards, but there was a rotation of the probe in the sagittal plane, following the movement of the PFM.

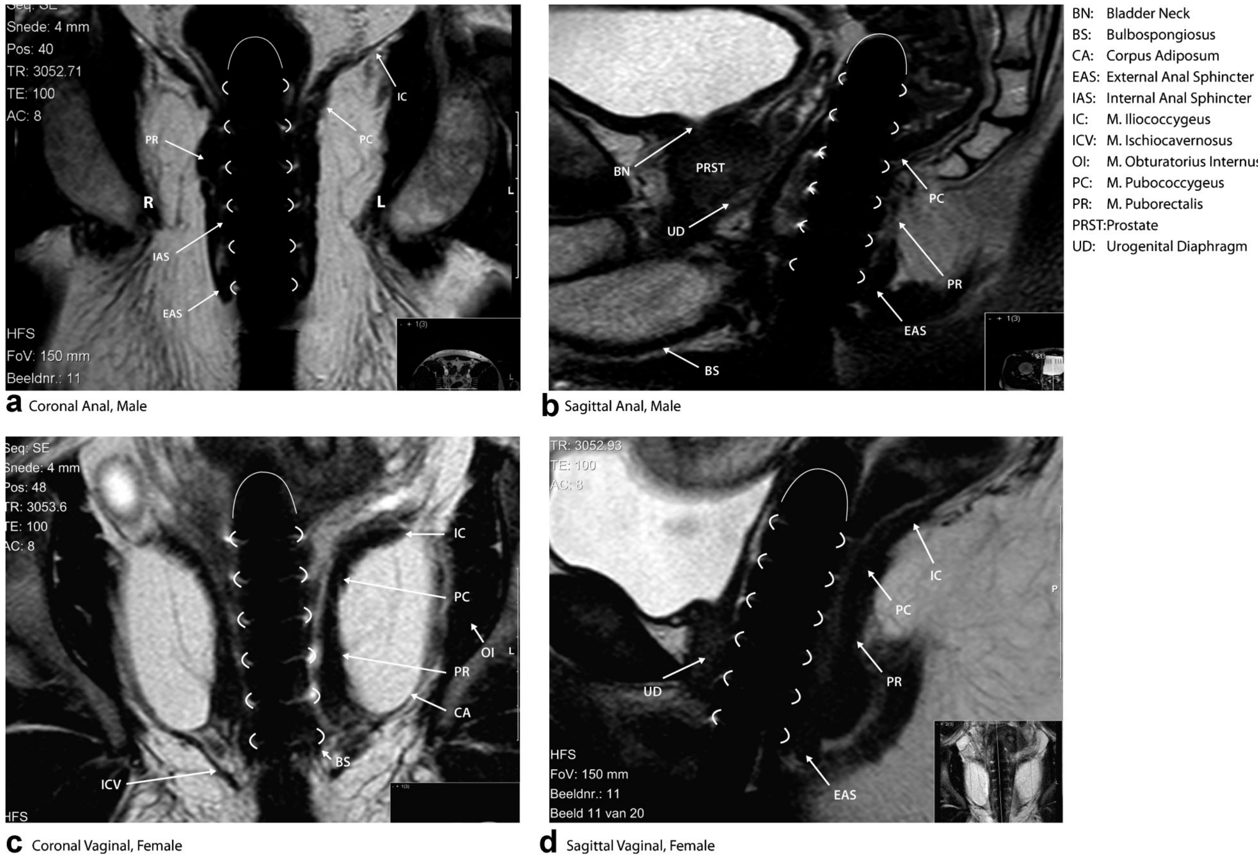

Fig. 2. MRI images.

During the cough and valsalva movement, the coccyx and ARA move downwards and backwards, away from the pubic symphysis. Dynamic MRI also revealed displacement of the probe relative to the vaginal or anal wall during cough and valsalva, which resulted in motion artifacts in the EMG signals. Therefore, cough and valsava were omitted.

Reliability

Test–retest reliability was performed on a random group of volunteers from all groups (N = 20). The ICCs for the different cases (groups and actions) are reported in Table II. The reliability was moderate (ICC between 0.5 and 0.7) in six of the cases, the reliability was good (between 0.7 and 0.9) in 14 of the cases and excellent (>0.9) in one case.

Anal Measurements

Figure 3 shows the mean EMG values and their standard errors for tone at rest, MVC and endurance measured at the right side of the electrodes nearest to the pubococcygeus muscle, the puborectalis muscle and the EAS for anal measurement in men and women. First the differences within the groups will be described and thereafter the differences between the groups.

In men, significant differences were seen between the EMG values nearest to the puborectalis muscle and the EAS for tone at rest ($P = 0.0001$), and between the EMG values nearest to the pubococcygeus muscle and the EAS for MVC ($P = 0.02$).

In nulliparous premenopausal women, significant differences were seen between the EMG values nearest to the pubococcygeus muscle and the puborectalis muscle ($P = 0.004$),

TABLE II. Intraclass Correlation Per Group, Per Action, Vaginally, and/or Anally

Type	Anal			Vaginal		
	Action			Action		
Group	**Rest**	**MVC**	**Endurance**	**Rest**	**MVC**	**Endurance**
Men	0.61	0.53	0.70	—	—	—
Women nulliparous premenopausal	0.76	0.60	0.79	0.73	0.60	0.74
Women parous premenopausal	0.91	0.71	0.75	0.85	0.71	0.67
Women parous postmenopausal	0.70	0.77	0.54	0.80	0.77	0.74

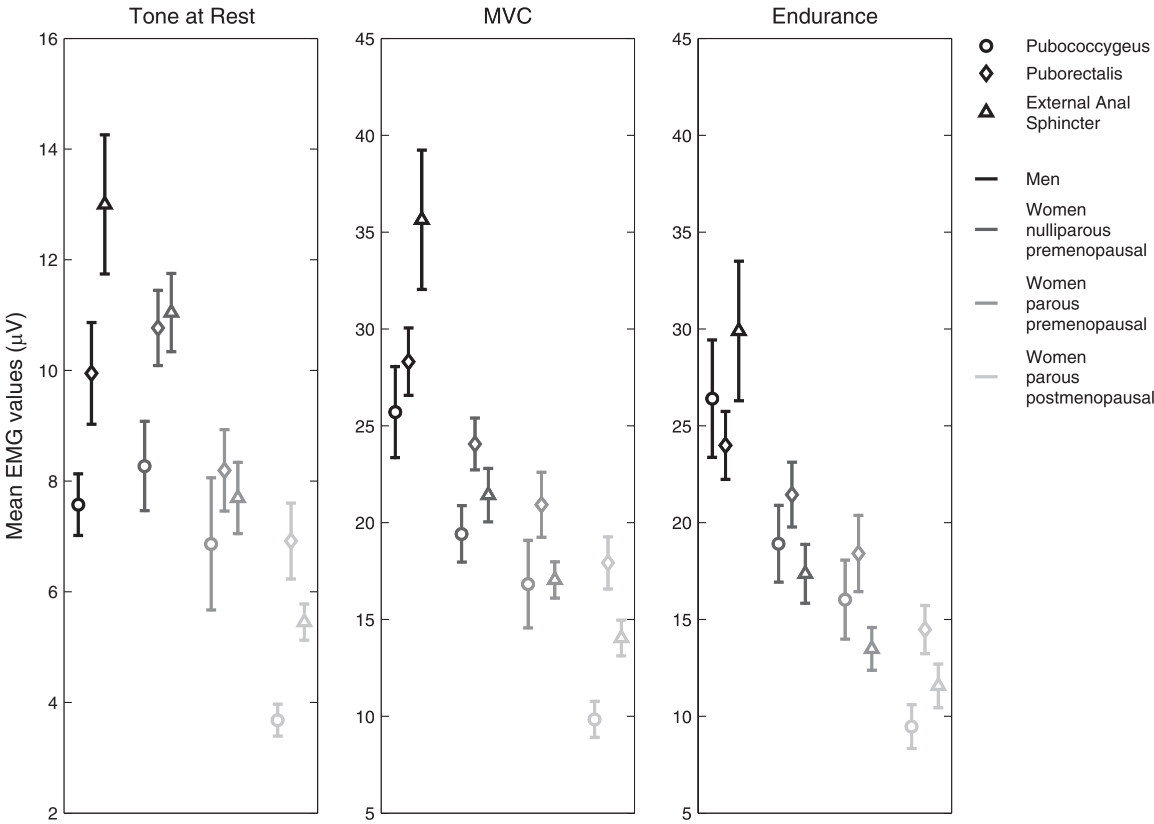

Fig. 3. Anal measurements.

and between the EMG values nearest to the puborectalis muscle and the EAS ($P = 0.02$) for tone at rest. In parous premenopausal women, there were no significant differences between the EMG values of the electrodes nearest to the muscles.

In parous postmenopausal women, significant differences were seen between the EMG values nearest to the pubococcygeus muscle and the puborectalis muscle for tone at rest ($P = 0.0001$). In terms of MVC, significant differences were also seen between the EMG values nearest to the pubococcygeus muscle and the puborectalis muscle ($P = 0.0001$), and between the puborectalis muscle and the EAS ($P = 0.05$). In terms of endurance, significant differences were observed between the EMG values nearest to the pubococcygeus muscle and puborectalis muscle ($P = 0.01$).

Within the groups, there were no significant differences between the mean EMG values for the left and right side nearest to the pubococcygeus muscle and the puborectalis muscle or the EAS.

Pubococcygeus Muscle

Average tone at rest EMG values nearest to the pubococcygeus muscle revealed significant differences between men and parous postmenopausal women ($P = 0.02$) and between nulliparous women and parous postmenopausal women ($P = 0.001$).

In terms of the MVC nearest to the pubococcygeus muscle, significant differences were seen between men and parous premenopausal women ($P = 0.01$) and between men and parous postmenopausal women ($P = 0.0001$).

For endurance nearest to the pubococcygeus muscle revealed significant differences between men and parous premenopausal women ($P = 0.02$) and parous postmenopausal women ($P = 0.001$), and between nulliparous premenopausal women and parous postmenopausal women ($P = 0.004$).

Puborectalis Muscle

The average EMG values for tone at rest nearest to the puborectalis muscle were significantly higher between nulliparous women and parous postmenopausal women ($P = 0.03$). For MVC nearest to the puborectalis muscle, average EMG values revealed significant differences between men and parous premenopausal women ($P = 0.01$) and parous postmenopausal women ($P = 0.0001$), and between nulliparous premenopausal women and parous postmenopausal women ($P = 0.03$). For endurance, no significant differences were found.

External Anal Sphincter

There were significant differences in the average EMG values for tone at rest nearest to the EAS between men and parous premenopausal women ($P = 0.001$) and parous postmenopausal women ($P = 0.0001$), and between nulliparous women premenopausal and parous postmenopausal women ($P = 0.001$).

MVC nearest to the EAS revealed significant differences between men and women of all groups ($P = 0.0001$). Similarly, there were significant differences in terms of endurance between men and women of all groups ($P = 0.0001$).

Vaginal Measurements

Significant differences were seen between the left and right side of the pelvic floor in all groups of women ($P < 0.05$). In all groups of women, significantly higher average EMG values were seen for the right side of the pelvic floor compared to the left side.

The observed left–right differences bore no relationship to the orientation of the probe or to left- or right-handedness of the volunteers, nor was it related to whether the researchers held the probe in their left or right hand. The results that follow only include the right side of the pelvic floor. Figure 4 shows the mean EMG values and their standard errors for the right side nearest to the pubococcygeus muscle, the puborectalis muscle and the bulbospongiosus and ischiocavernosus muscles.

In nulliparous premenopausal women, significant differences were seen between the EMG values nearest to the pubococcygeus muscle and the puborectalis muscle ($P = 0.0001$), and between the puborectalis muscle and the bulbospongiosus and ischiocavernosus muscles ($P = 0.001$) for tone at rest, MVC and endurance.

In parous premenopausal women, there were significant differences between the EMG values nearest to the pubococcygeus muscle and the puborectalis muscle ($P = 0.01$) for MVC, and between the puborectalis muscle and the bulbospongiosus and ischiocavernosus muscles ($P = 0.03$) for endurance.

In parous postmenopausal women, there was a significant difference between the EMG values nearest to the puborectalis muscle and the bulbospongiosus and ischiocavernosus muscles ($P = 0.04$) for MVC.

Pubococcygeus Muscle

There were no significant differences in tone at rest, MVC and endurance nearest to the pubococcygeus muscle between the groups.

Puborectalis Muscle

Significant differences were seen in EMG values nearest to the puborectalis muscle in tone at rest between nulliparous premenopausal women and both parous premenopausal women ($P = 0.009$) and parous postmenopausal women ($P = 0.004$). In terms of MVC, there were significant differences between nulliparous premenopausal women and both parous premenopausal women ($P = 0.02$) and parous postmenopausal women ($P = 0.03$).

In terms of endurance, there were significant differences between nulliparous premenopausal women and either parous premenopausal women ($P = 0.02$) or parous postmenopausal women ($P = 0.03$).

Bulbospongiosus and Ischiocavernosus Muscles

Nearest to the bulbospongiosus and ischiocavernosus muscles, tone at rest was significantly different between nulliparous premenopausal women and either parous premenopausal women ($P = 0.007$) or parous postmenopausal women ($P = 0.003$). Similarly, MVC was significantly different in nulliparous premenopausal women compared to parous premenopausal women ($P = 0.03$). Finally, in terms of endurance, significant differences were seen between nulliparous

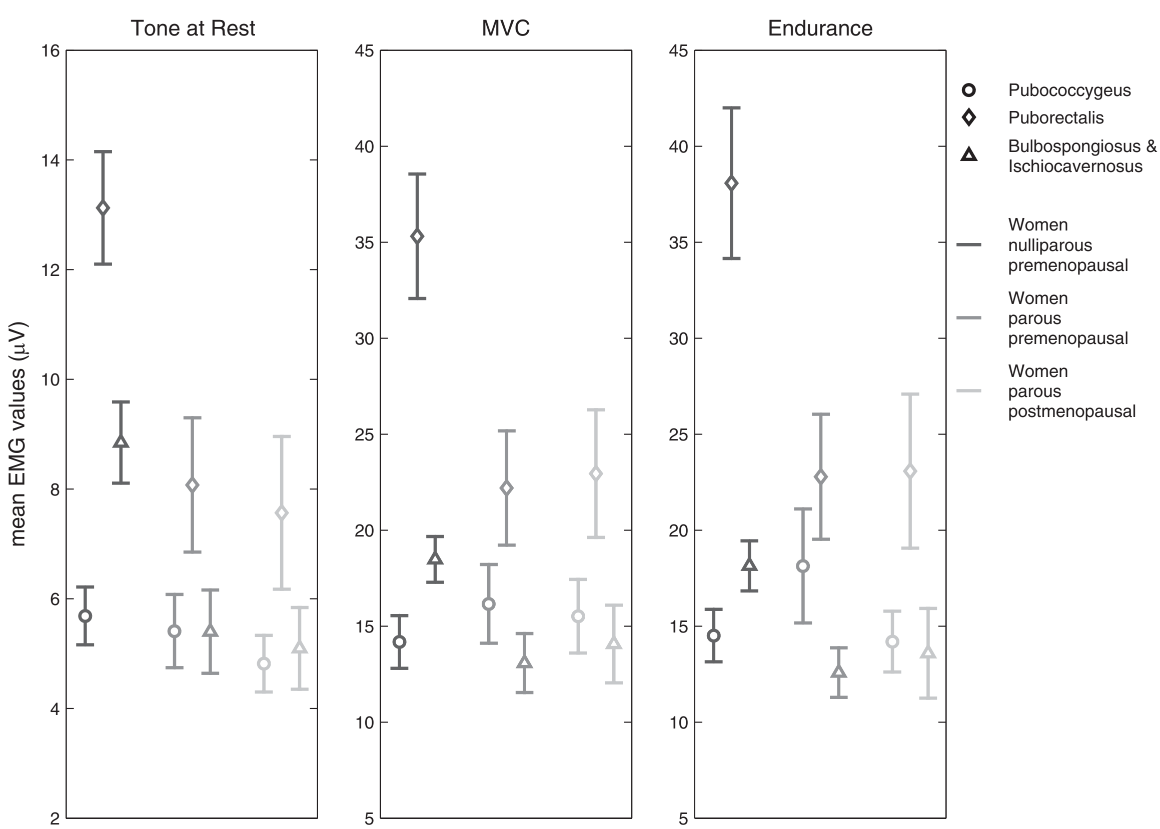

Fig. 4. Vaginal measurements.

premenopausal women and parous postmenopausal women ($P = 0.03$).

General Remarks

There was no significant difference in tone at rest after MVC in any of the groups, although it was slightly lower in most cases.

The EMG signals from the surface electrodes registering the activity of abdominal, gluteal, and adductor muscles showed only a slight increase in activity compared to the probe EMG signals.

DISCUSSION

The aims of this study were to determine the reliability of the EMG signals measured with the MAPLe, to determine the differentiation of the different muscles of the pelvic floor and to determine the differentiation between the different groups of volunteers.

As far as we know, this is the first study to investigate the EMG values for the different sides and levels of the pelvic floor musculature and to assess normal pelvic floor function in large groups of healthy volunteers.

The results for the test–retest reliability, the ICCs showed moderate to excellent reliability for anal and vaginal measurement for rest, MVC, and endurance.

The results showed that there are significant differences in average EMG values nearest to the different muscles within men and women, and between nulliparous and parous women, pre- and postmenopausal and that there are significant differences in average EMG values between the groups. The results also showed that there are significant differences between the left and right side of the pelvic floor in women.

In our study, the average EMG values found using the MAPLe at rest, during MVC and for endurance are different from those reported for commercially available probes. However, with the commercially available probes, an objective comparison cannot be made because the different devices come in various shapes and sizes,[14,23,24,30,31] and the measurement outcomes are quoted in different parameters. Therefore, further comparison of our results with those of other devices is not warranted.[1,31]

In the present study, we observed asymmetry in the PFM activation. Although most researchers neglect to discuss the relationship between the different sides of the PFM,[28,32] there is evidence in the literature to suggest that the superficial and deeper layers of the PFM should be assessed separately,[33,34] as well as the balance between the left and right sides.[20,25,35–37] Several studies have indicated that a measured increase in EMG PFM activity in PFD is due to the inability of the commonly available probes to distinguish between left and right sides and deeper and more superficial aspects of the pelvic floor.[38,39] Moreover, it is suspected that healthy volunteers contract their PFM bilaterally as a functional unit[40] but that, following vaginal delivery, partial denervation of the PFM, and/or unilateral damage[25,41] may result in asymmetric activation[42]. Other authors stated that functional asymmetry of pelvic floor innervation has been shown to exist in healthy volunteers[43,44] and has been demonstrated for the central and peripheral compartments of the motor pathways to the pelvic floor. Overall, although the evidence describing symmetry and asymmetry of right and left-sided PFM activation remains inconclusive, our results do indicate that further research in patients is necessary to improve the diagnostic and therapeutic procedures relating to PFD.

Intra-abdominal pressure caused by coughing and valsalva invariably modulates intra-vaginal and intra-anal pressure, and EMG signals can further confound the accuracy of PFM contraction and strength measurements. Therefore, measurements are only valid if a simultaneous observation of inward movement of the perineum or measurement device during the tasks can be confirmed.[45] If the probe moves inwards, it is unlikely that there is a significant increase in abdominal pressure and it is probable that a correct contraction with squeeze and inward/forward lift has been accomplished.[46]

We used ultrasound and MRI to check the placement of the probe and PFM function in a random group of volunteers. Although we noted displacement of the PFM and the os coccygis and anorectal angle (ARA) ventrally towards the symphysis during MVC and endurance, the electrodes did not move with respect to the vaginal or anal wall. The probe was not tilted inwards, but there was a rotation of the probe in the sagittal plane, following the movement of the PFM.

Moreover, dynamic MRI during cough and valsalva also revealed that the os coccygis and ARA move downward/backward away from the symphysis and that the probe is displaced relative to the pelvic floor anatomy. There is also ultrasound or MRI evidence in the literature that a voluntary contraction of the pelvic floor musculature changes the ARA[19] and can displace the urethra and rectum towards the symphysis.[19,47] Our study confirms that, during cough and valsalva, a reliable registration of EMG values is not possible due to displacement of the probe.

The validity of EMG recordings of the PFM may be threatened by crosstalk and motion artifact. Therefore, based on well-established standards, vaginal and anal EMG probes should be designed in such a way as to minimize the stretch imposed on the PFM, and they should comprise small electrode surfaces that are close together, provide different signals, and should not move with respect to the vaginal wall or the anal canal. This movement should be prevented by the pelvic floor physiotherapist when holding the probe. The MAPLe has been designed to fulfil all these requirements.

The MAPLe has shown to be a reliable measurement device to register EMG activity of different muscles of the pelvic floor and their sides. In the future, the MAPLe can be used for diagnosis and treatment of pelvic floor dysfunction in clinical practice and in research. The MAPLe can be used for the development of standardized diagnosis and treatment protocols in clinical practice.

CONCLUSIONS

The MAPLe is a reliable instrument measuring the EMG signals of the different sides and levels nearest to the pelvic floor musculature and is capable to differentiate between men and women, nulliparous and parous, pre- and postmenopausal. The findings of this study have implications for the diagnosis and treatment of pelvic floor dysfunction in the future and the outcomes of this study can be used as a healthy baseline for the diagnosis and treatment of patients.

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