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Pelvic floor muscle function after grade II tears—Surface electromyography test–retest and differences between nulliparous and primiparous

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Abstract

Background: Vaginal birth is a risk factor for weakening of the pelvic floor muscles (PFM) and development of pelvic floor dysfunction (PFD). Perineal tears may decrease PFM function. PFM tone can be assessed with surface EMG (sEMG), but reliability studies of sEMG in women with perineal tears are lacking. The aims of this study were to evaluate test–retest and intrarater reliability of sEMG and compare PFM activation between nulliparous and primiparous.

Methods: A sEMG test–retest was performed in 21 women (12 nulliparous and 9 primiparous with grade II tears) to assess intra-rater reliability during rest and maximal voluntary contraction (MVC) of the PFM. Intraclass Correlation Coefficient (ICC), standard error of measurement (SEM) and minimal detectable change (MDC) were tested. A comparison between nulliparous' and primiparous' PFM activation during rest and MVC was performed.

Results: sEMG demonstrated fair reliability in nulliparous (ICC: 0.239; SEM: 5.2; MDC: 14.5) and moderate reliability in primiparous (ICC: 0.409; SEM: 1.5; MDC: 4.2) during rest. For peak MVC very good intrarater reliability was found in nulliparous (ICC: 0.92; SEM: 8.0; MDC: 22.2) and in primiparous (ICC: 0.823; SEM: 8.0; MDC: 22.2). Statistically significant lower PFM activation was found in primiparous women with perineal tear grade II than in nulliparous at rest (mean difference 9.1 μV, 95% confidence interval [CI] 3.0–19.0, $p = 0.001$), and during MVC_{peak} (mean difference 50.0 μV, 95% CI 10.0–120.0 $p = 0.021$).

Abbreviations: AI, anal incontinence; ICC, intraclass correlation coefficient; MDC, minimal detectable change; MVC, maximal voluntary contraction; PFD, pelvic floor dysfunction; PFM, pelvic floor muscles; POP, pelvic organ prolapse; SEM, standard error of measurement; sEMG, surface electromyography; UI, urinary incontinence.

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Conclusions: sEMG is reliable when measuring PFM activation in primiparous women with perineal tears grade II. Women with perineal tears grade II have lower PFM activation both during rest and MVC.

KEYWORDS
grade II perineal tears, pelvic floor muscles, reliability, surface electromyography

1 | INTRODUCTION

The first vaginal delivery may severely interfere with pelvic floor anatomy and function.[1] It can cause pelvic floor dysfunction (PFD), such as urinary and anal incontinence (UI, AI), pelvic organ prolapse (POP), sexual dysfunction, and pelvic pain, conditions that strongly affect women's quality of life.[2–4] Pelvic floor trauma during vaginal birth involves injuries to the pelvic floor muscles (PFM), connective tissue, peripheral nerves, and the perineum.[5] Severity of perineal tears is graded between I-IV and classified with subdivisions.[6,7] Perineal tears grade II involve the perineal muscles while grades III and IV also affect the anal sphincter and anal mucosa.[6,8]

The prevalence of perineal tears during birth varies between 53% and 79%, a majority of which are first and second-degree tears.[8]

III and IV degree perineal tears have had the main focus, concern, and follow-up from obstetricians, gynecologists, midwives and physical therapists, but there is still insufficient knowledge of consequences and treatment for lower grade perineal tears.[9]

Sundquist et al.[10] compared women with and without sphincter tears and found that dyspareunia and perineal pain were present in 18%–23% of women in the tear groups compared with 9%–12% of those without a tear. Almost 45% of women with initial symptoms had problems after 4 to 8 years. To date, there is sparse knowledge of whether the tone and strength of the PFM are affected by perineal tears of any degree, particularly the most prevalent and less severe ones (grade I and II), and whether this is associated with PFD.[11,12]

Various methods are used to evaluate PFM tone, activation, and strength, including observation, digital vaginal palpation, electromyography, manometry, dynamometry, ultrasonography, and magnetic resonance imaging.[3] Surface EMG (sEMG) using a vaginal probe has been shown to be a reliable method for assessing PFM tone and activation in healthy women and may provide critical information for comparison and intervention studies.[13,14] However, to our knowledge, the reliability of this method in women with perineal tears has not been investigated.

Grade II perineal tears require surgical repair as they affect the perineal muscle fibers.[6] The muscle activation of the PFM is likely affected in women with grade II tears and may contribute to PFD both in the short and long term. However, to assess the influence of perineal tears grade II on PFM activation, it is necessary first to test the reliability of the measurement method.

Therefore, the present study aimed to evaluate the test–retest intra-rater reliability of a sEMG device (Physioplux clinical) in nulliparous and primiparous women with perineal tears grade II after delivery. Additionally, to compare sEMG PFM activation between nulliparous and primiparous women with grade II perineal tears.

2 | MATERIALS AND METHODS

2.1 | Study design

This was a test–retest study evaluating intrarater reliability of sEMG of the PFM during rest and MVC. Two test series were performed on the same day at an interval of 10 min. In addition, PFM activation during rest and MVC were compared between nulliparous and primiparous women with perineal tears grade II.

2.2 | Participants

Twenty-one women participated in the study (12 nulliparous and 9 primiparous women with perineal tears grade II).

Nulliparous women were recruited within the network of personal contacts (colleagues, friends, and family), and primiparous women were recruited in the labor ward of Hospital de Santa Maria immediately after birth by the obstetricians between January 2020 and March 2021. Due to the sars COV 19 pandemic restrictions, the recruitment only took place for a few

months during this period. All the recruited women were contacted by phone by the physiotherapists in the research team 3 weeks after birth. The ones who agreed to participate volunteered to come to the university or were visited in their homes. The actual measurements were undertaken 5–6 weeks after recruitment.

The inclusion criteria for the nulliparous women were being healthy and aged 20–35. Inclusion criteria for primiparous women were women with one vaginal birth and a perineal tear grade II, diagnosed by the medical staff of gynecologists and obstetricians of the Hospital de Santa Maria, immediately after birth.

Exclusion criteria for both groups were: women who had undergone pelvic surgery, women with neurological disorders that may influence PFM activation, women with severe pelvic floor pain not allowing the placement of the vaginal probe [11,13], and women who were unable to perform a correct PFM contraction.

The study was approved by the Ethics Committee of University Hospital Center Lisbon North and Lisbon Academic Medicine Center (408/9). The participants were informed about the aim and risks of the study and gave their written consent.

2.3 | Procedures and data collection

2.3.1 | Study protocol

Initially, women were instructed on how to perform a correct PFM contraction, defined as an inward lift and squeeze around the pelvic openings. Images and anatomical models were used to explain the anatomy and function of the pelvic floor, and vaginal palpation was performed to ensure the ability to contract.[13,15–18]

Before the experiment began, participants were asked to empty their bladders. Then, they entered a supine position with hips flexed at 45° and slightly abducted, knees flexed at 90° with feet resting on the table.[13,17]

The assessment of a correct PFM contraction was done by digital palpation. If the patients could not correctly contract the PFM or reported pain during palpation, they were excluded. Two participants (one nulliparous and one primiparous) were excluded before the introduction of the probe because of pain during palpation.

The measurements of muscle activation of the PFM were performed with the pelvis in a neutral position.[16] To control accessory muscles activation (gluteal, abdominals, and adductors) and ensure an isolated activation of PFM, two self-adhesive electrodes were placed on the rectus abdominis (RA) muscle (unilaterally on the right, parallel to the muscle fibers, approximately 2 cm laterally from the umbilical scar) and two on the adductor (ADD) muscle of the right hip (placed at an oblique angle on the medial aspect of the thigh, 4 cm from the pubis). The reference electrode was placed on the right anterior superior iliac spine.

After the electrodes were placed in position, the Periform probe (Neen UK) was carefully inserted into the vagina using water-soluble lubricant to increase the contact area and decrease discomfort during introduction.[16,17]

Before the measurements, to avoid any voluntary PFM activity during the rest assessment, the participants were instructed to breathe in and out and try to be as relaxed as possible to avoid any voluntary PFM activity during the resting period.[14] The baseline resting tone was collected during 4 s. After the assessment during rest, the participants were instructed to perform three MVC of the PFM, each lasting 4 s, with 1-min rest between contractions.[16] The verbal command was "tighten the probe and lift it as much as you can with minimal or no use of abdominal, hip or gluteal muscles during PFM contraction."[18,19]

To perform the test–test intrarater reliability, the whole procedure was repeated after 10 min of rest. Additionally, the first assessment was used to compare PFM sEMG activation at rest and peak of three MVCs between nulliparous and primiparous women with perineal tears grade II.

2.3.2 | Instruments

sEMG (Physioplux Clinical) and a Periform intravaginal probe were used to assess PFM variables. The Physioplux Clinical is a small, portable electromyography device that includes four sEMG sensors. It includes wireless Bluetooth connectivity and is marked as portable and easy to use (Figure 1).

The muscle signal is detected by sEMG sensors placed on the user's skin, which are connected to the signal transmission device called biosignals Plux. The biosignals Plux receives and digitizes the signal collected by the

FIGURE 1 Surface EMG (*Physioplux Clinical)* and vaginal probe (*Periform*), with copyright permission of PLUX Biosignals.

sEMG sensors, transmitting via Bluetooth, in real-time, to the tablet. The channels of biosignals Plux have a resolution of 16 bits, and a sampling frequency of 1000 Hz. The Periform is a pear-shaped probe with electrodes on each side and, therefore, less prone to intravaginal movements.[16,20]

The Periform probe has been shown to have good intra-session reliability for repeated PFM MVC.[13,15] Periform has two stainless-steel electrode bars laterally located with a surface area of 3.5 × 1.5 cm each and an electrode distance of 3.4 cm and were positioned longitudinally over the abdominal and adductor muscles.[16] The size of the Periform electrode surfaces record less baseline noise than smaller electrode surfaces, but the probability of crosstalk increases [11]. To minimize possible crosstalk from other muscles, a correct and isolated PFM activation was controlled monitoring the contraction of the accessory muscles (RA and ADD) as described above.[16,20]

2.4 | Statistics methods

All statistical analyses were performed using SPSS Statistics for Windows (Version 23.0). Background data are presented as numbers with percentages (n/%) and means with standard deviation (SD).

The intrarater reliability was calculated using the intraclass correlation coefficient (ICC), for the two-way mixed model.

The Altman scale was used for the classification of reliability values. ICC values less than or equal to 0.20 were considered poor, 0.21 to 0.40 fair, 0.41 to 0.60 moderate, 0.61 to 0.80 good, and 0.81 to 1.00 very good.[21] Additionally, the Standard Error of Measurement (SEM) and the minimal detectable change (MDC) were calculated using a 95% confidence interval (CI).[16,17] SEM was calculated using: $SEM = SED^{*}\sqrt{1 - ICC}$. The MDC was calculated using:

$$MDC = SEM \times 1.96 \times \sqrt{2}.$$

To assess possible differences in muscle activation between nulliparous and primiparous women with perineal tears grade II, a nonparametric statistic approach was performed ($N < 30$). Differences between groups in sEMG were analyzed use Mann–Whitney test.

Significance level was set at <0.05.

3 | RESULTS

We included 21 women (12 nulliparous and 9 primiparous with perineal tears grade II). Table 1 shows the background variables. The primiparous group had significantly higher BMI ($p = 0.004$) and lower education level than the nulliparous control group ($p = 0.024$).

Table 2 shows the sEMG intrarater reliability results. During rest, the sEMG showed fair reliability in evaluating nulliparous women and moderate reliability in primiparous women with perineal tears grade II. The SEM and MDC values were high in both groups during rest and MVC_{peak}. During MVC_{peak} the primiparous women with perineal tears grade II demonstrated the same very good intrarater reliability as the nulliparous women.

Primiparous women with perineal tears grade II had statistically significantly lower PFM activation both during rest, mean difference 9.1 μV, 95% CI 3.0–19.0, $p = 0.001$, and during MVC_{peak}, mean difference 50.0 μV, 95% CI 10.0–120.0 $p = 0.021$ (Table 2).

4 | DISCUSSION

The ICC results of the present study showed that sEMG during rest was fair in nulliparous but moderate in primiparous women with perineal tears grade II. Both groups had very good intrarater reliability in MVC_{peak}. Women with perineal tear grade II had significantly lower sEMG activation of the PFM both during rest and maximal MVC than nulliparous women.

Most studies consider sEMG a reliable instrument to measure muscle activation during rest of the PFM,[13,14,18] as it is easier to avoid cross-talks from accessory muscles during rest than during activations of other muscle groups.[14] However, in the present study, the ICC values were lower

TABLE 1 Background variables.

	Nulliparous $n = 12$	Primiparous $n = 9$
Age (min–max; mean ± SD)	24–33; 28.7 ± 3.1	27–35; 30.2 ± 3.1
BMI (min–max; mean ± SD)	19.6–25,0; 21.6 ± 1.9	20.7–31.8; 26.7 ± 3.8
University education *n* (%)	12 (100%)	5 (56%)

Note: Descriptive variables: Values represented with minimum (min) and maximum (max); mean and standard deviation (SD); subject number (*n*); number of subjects in percentage (%); BMI (body mass index).

	Rest		MVC	
	Nulliparous	Primiparous with perineal tear grade II	Nulliparous	Primiparous with perineal tear grade II
Mean ± SD (μV)	16.0 ± 6.0	6.0 ± 2.0	58.0 ± 29.0	36.2 ± 19.0
ICC (95% CI)	0.24 (0.05;0.56)	0.41 (0.15;0.76)	0.92 (0.84;0.97)	0.82 (0.64;0.95)
SEM (μV)	5.2	1.5	8.0	8.0
MDC (μV)	14.5	4.2	22.2	22.2
Mann–Whitney U[a]	9.50		25.00	
p Value	0.001		0.021	

Abbreviations: CI, confidence interval; ICC, intraclass correlation coefficient; MDC, minimal detectable change; MVC, maximal voluntary contraction; SEM, standard error of measurement; μV, microvolt.
[a]Mann–Whitney U between nulliparous and primparous.

TABLE 2 Test–retest intrarater reliability and comparison between sEMG PFM activation at rest and during MVC in nulliparous ($n = 12$) and primiparous women with perineal tear grade II ($n = 9$).

during rest than during MVC. Unlike most skeletal muscles, the PFM has constant EMG activity to maintain urinary and anal continence and support of pelvic/abdominal contents. The activation level at rest may be influenced by bladder fullness,[22] pelvis position, respiratory function, and anxiety. It can potentially also be related to pelvic floor discomfort, for example during and after the insertion of a vaginal probe. Additionally, the finding of the present study that the nulliparous women had fair intratester reliability compared to moderate in the perineal tear grade II group, may be due to differences in size, shape, and looseness of the vagina between the two groups. A possible explanation of this difference may be that due to a narrower vagina in nulliparous women, they could have experienced more discomfort with the introduction of a vaginal probe than women 5 to 6 weeks after vaginal birth. However, this hypothesis needs further studies.

The test–retest intrarater reliability of sEMG of MVC_{peak} in this study was very good, which is in line with other reliability studies on sEMG of the PFM.[13,14,18,20] However, these studies were performed in healthy nulliparous women without any perineal trauma,[13,18] or in women with different parity and after the postpartum period,[14] in whom it could be potentially easier to achieve a reliable measure of PFM activation. To our knowledge this is the first reliability study on sEMG of the PFM in women with perineal tears, and as the ICC values were very high for MVC, this means it can be used to assess muscle activation in this group of primiparous women with perineal tears grade II. Muscle activation is estimated by measuring the amplitude of the sEMG signal, which refers to the number of microvolts (μV) a muscle generates [3] giving a measure of the actual amount of sEMG activity in μV or an average μV value. The results found in this study on amplitude of the sEMG activity in primiparous women during MVC are in line with the results found by Guo et al.[23] on primiparous women with spontaneous delivery. We have not been able to find reference values for SEM and MDC. The SEM values found in our study varied between 2 and 8 μV and the MDC values varied between 4 and 22 μV. These results are relatively high and in line with those described by Koenig et al.[16] and Scharschmidt et al.[17] which may affect the reliability of this instrument. The results should therefore be considered with caution. These relatively high SEM and MDC values could be explained by some participants not being able to maintain the PFM contraction for 4 s, or achieving complete relaxation after the MVC.[16,17]

Higher electromyographic values have been found to correlate with greater muscle fiber recruitment and greater muscle strength. However, it is not a direct measurement of strength as strength is a function of both neural factors and the cross sectional area of the muscle.[16] PFM strength can be measured with manometry and dynamometry.[14] As PFM strength and activation is not the same, to date there is no consensus which gold standard should be used to validate sEMG.

Our results showed that sEMG PFM activation values were lower in primiparous women with perineal tears grade II both during rest and in MVC, although the CI are wide probably related to the sample size. The lower resting tone and MVC in this group may be due to denervation leading to less recruitment of motor units and/or tear of PFM fibers causing diminished strength. Our results are comparable and in line with Guo et al.[23] where women who delivered by cesarean section, without perineal tears had higher values of sEMG PFM activation than women with spontaneous or forceps delivery. Although tears grade III and IV are the most severe perineal tears,[10] there is a growing concern also about

consequences after II degree perineal tears. The findings of the present study suggest that also grade II tears can have a negative impact on PFM activation, with potential future development of PFD.[23,24] Further research is needed to study associations with reduced EMG activation and PFD in women with perineal tears grade II, and prospective studies are needed to investigate long-term effects. A closer follow-up of women with perineal tears grade II may be important to prevent and treat PFM weakness and PFD. A Cochrane review[25] found short-term effect of PFMT in the treatment of UI in the postpartum period, but there was no report of neither specific randomized controlled trials (RCTs) in the group of women with III-IV degree perineal tears nor grade II in this systematic review. Future RCTs are warranted for these subgroups of postpartum women.

4.1 | Strengths and limitations

To our knowledge this is the first reliability study of sEMG including women with perineal tears grade II and the first comparison study of PFM activation between nulliparous and women with perineal tears grade II postpartum.

All women were controlled for ability to contract the PFM with vaginal palpation, and a standardized protocol was developed to increase reliability [10]. To minimize possible crosstalks, all participants were thoroughly instructed to do a correct and isolated contraction of the PFM before the evaluation. Accessory muscles (abdominal and adductor muscles) were controlled through sEMG electrodes.

A limitation of the study was the small sample size and lack of an "a priori" power calculation. The latter was mainly due to lack of available relevant studies. The results of the present study may therefore serve as a basis for future sample size calculations. Furthermore, we did not have any data on PFD and no further follow-up of PFM activation beyond 5–6 weeks. Additionally, there were statistically significant differences in BMI and education level between nulliparous and primiparous groups. The higher BMI in primiparous group may be related to weight gain during pregnancy as our measurements were conducted in the early postpartum period. As this weight gain might be temporary and related to pregnancy, it may not induce PFM changes and interfere with PFM activation in the long term. It is not clear whether education level can be related to sEMG results. This needs further investigation.

5 | CONCLUSIONS

sEMG has shown acceptable intra-rater reliability and can be recommended in the evaluation of PFM activation in primiparous women with perineal tears grade II, despite the relatively high values of SEM and MDC. Grade II tears negatively influence PFM activity both during rest and MVC in primiparous women 5–6 weeks after vaginal birth. Further research is needed to follow-up women with perineal tears grade II postpartum.

AUTHOR CONTRIBUTIONS

Patrícia Mota: Protocol/project development, data analysis, manuscript writing, critical revision of the article. **Ana Costa**: Data collection; data analysis; manuscript writing; critical revision of the article. **Diana Santos**: Data collection; data analysis; manuscript writing; critical revision of the article. **Susana Santo**: Protocol/project development, sample recruitment, critical revision of the article. Joana G. Barros: Protocol/project development, sample recruitment, Critical revision of the article. Kari Bø: Protocol/project development, manuscript writing, critical revision of the article. All authors contributed to the approval of the final version to be published.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author, P. M.

ETHICS STATEMENT

The study was approved by the Ethics Committee of University Hospital Center Lisbon North and Lisbon Academic Medicine Center (408/9). The participants were informed about the aim and risks of the study and gave their written consent.

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