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ORIGINAL ARTICLE

Too tight to give birth? Assessment of pelvic floor muscle function in 277 nulliparous pregnant women

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Abstract
Introduction and hypothesis Theoretically, tight or strong pelvic floor muscles may impair the progress of labor and lead to instrumental deliveries. We aimed to investigate whether vaginal resting pressure, pelvic floor muscle strength, or endurance at midpregnancy affect delivery outcome.
Methods This was a prospective cohort study of women giving birth at a university hospital. Vaginal resting pressure, pelvic floor muscle strength, and endurance in 300 nulliparous pregnant women were assessed at mean gestational week 20.8 (±1.4) using a high precision pressure transducer connected to a vaginal balloon. Delivery outcome measures [acute cesarean section, prolonged second stage of labor (> 2 h), instrumental vaginal delivery (vacuum and forceps), episiotomy, and third- and fourth-degree perineal tear) were retrieved from the hospital's electronic birth records.
Results Twenty-three women were lost to follow-up, mostly because they gave birth at another hospital. Women with prolonged second stage had significantly higher resting pressure than women with second stage less than 2 h; the mean difference was 4.4 cmH_2O [95 % confidence interval (CI) 1.2–7.6], $p<0.01$, adjusted odds ratio 1.049 (95 % CI 1.011–1.089, $p=0.012$). Vaginal resting pressure did not affect other delivery outcomes. Pelvic floor muscle strength and endurance similarly were not associated with any delivery outcomes.
Conclusions While midpregnancy vaginal resting pressure is associated with prolonged second stage of labor, neither vaginal resting pressure nor pelvic floor muscle strength or endurance are associated with operative delivery or perineal tears. Strong pelvic floor muscles are not disadvantageous for vaginal delivery.

Keywords Delivery · Endurance · Pelvic floor · Strength · Second stage · Vaginal resting pressure

Introduction

A recent Cochrane review concluded that pregnant women without prior urinary incontinence (UI) who were randomized to intensive antenatal pelvic floor muscle training (PFMT) were 30 % less likely to report UI up to 6 months postpartum than women randomized to no PFMT or usual antenatal care [1]. Thus, women should be encouraged to perform PFMT during pregnancy to prevent UI [1]. However, there is scant knowledge about the influence of the pelvic floor muscles (PFM) on labor and delivery outcome [2, 3].

There has been some concern that a tight and strong pelvic floor might obstruct labor and result in instrumental delivery, perineal trauma, and/or injury of peripheral nerves, connective tissue, and muscles [3]. On the other hand, others suggest that stronger PFM may facilitate labor and vaginal childbirths [1]. Some studies have concluded that there is no increased risk of prolonged labor or operative deliveries after antenatal PFMT [4–7], whereas others have found higher rates of cesarean section [8]. However, none of these studies assessed objective measures of pelvic floor function in relation to delivery outcome.

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The aim of the present study was to investigate the influence of vaginal resting pressure (VRP), PFM strength measured as maximum voluntary contraction (MVC), and endurance at midpregnancy on delivery outcomes.

Methods

Participants

Three hundred nulliparous pregnant women participating in a prospective cohort study at Akershus University Hospital, Norway were recruited into this study. The women were recruited at their scheduled ultrasound assessment at gestational week 18 and met for their examination for the present study at mean gestational week 20.8 (± 1.4). The time period for inclusion was from January 2010 until April 2011. All women gave written informed consent to participate, and the study was approved by the Regional Medical Ethics Committee (2009/170), Norwegian Social Science Data Services (2799026), and registered at ClinicalTrials.gov (NCT01045135).

Inclusion criteria were being in their first ongoing singleton pregnancy and being able to understand a Scandinavian language. Exclusion criteria were multiple pregnancy or previous miscarriage after gestational week 16, premature birth <32 weeks, stillbirth, or serious illness of mother or child.

Assessment of the PFM

Ability to contract

Two trained physical therapists taught participants how to perform a correct PFM contraction. Correct contraction was defined as a squeeze around the pelvic openings and a lift of the perineum. Ability to perform correct contractions was verified by observation of inward perineal movement and vaginal palpation [9].

Measurement of VRP, PFM strength, and endurance

VRP, PFM strength expressed as MVC, and PFM endurance were measured using a high precision pressure transducer connected to a balloon catheter (Camtech AS, Sandvika, Norway). The method has demonstrated intraobserver reliability [10]. The balloon was placed according to the usual procedure with the middle of the balloon 3.5 cm from the vaginal introitus [11]. Only contractions with simultaneously visible inward movement of the catheter/perineum were considered correct [9]. Muscle endurance was measured as the area under the curve during an attempt to hold the contraction for 10 s [12]. Three MVC followed by a short resting period and one holding period were performed. All measurements were done in the supine crook-lying position.

Outcome variables

Delivery data were extracted from the hospital's electronic birth records. Medical personnel responsible for registering obstetrical data had no knowledge about the previous PFM assessment.

Cesarean sections were divided into either elective or acute. Women undergoing elective cesarean section were excluded from the analyses. Second stage of labor was defined as the interval between full cervical dilatation and birth of the child, and prolonged second stage of labor was defined as more than 2 h [13, 14]. Instrumental vaginal delivery was vacuum or forceps assisted delivery or both. Due to the low rate of forceps deliveries these variables are reported together. Third- and fourth-degree perineal tears were defined according to Sultan et al. [15] as disruption of the anal sphincter muscles which may be partial or complete (IIIa–c) without involvement of the anal epithelium. A fourth-degree tear includes disruption of the anal epithelium as well. Episiotomy was done per common Norwegian practice using a left side mediolateral incision. Induction was any non-spontaneous start of labor.

Statistical methods

Background variables are reported as means with SD or numbers with percentages. Differences between VRP, strength (mean of three MVC), and muscular endurance in women with and without acute cesarean section, prolonged second stage (>2 h), instrumental delivery, third- to fourth-degree perineal tear, and episiotomy are reported as means with 95 % confidence interval (CI) and analyzed by use of the Mann-Whitney or independent sample t test. The association of VRP, PFM strength, and endurance and each delivery outcome was also analyzed in separate models by logistic regression and reported as crude and adjusted odds ratios (cOR and aOR) with 95 % CI. We adjusted for maternal age, prepregnancy body mass index (BMI), birth weight, induction of labor, epidural, and head circumference. The p value was set to ≤0.05. With Bonferroni adjustment for five comparisons the alpha level is 0.01.

Results

Of the 300 participants 23 (7.7 %) were lost to follow-up, leaving 277 with delivery data. Of the 23 women lost to follow-up, 10 delivered at another hospital, 9 did not want to continue, 3 had a stillbirth, and 1 was excluded due to delivery before 32 weeks of gestation. Table 1 shows background characteristics of the 277 participating nulliparous pregnant women at midpregnancy [mean gestational week 20.8 (±1.4)]. Mean BMI was in the normal range, and most of the participants had higher education. Table 2 describes delivery variables of the study sample. There were no important differences

Table 1 Background characteristics of nulliparous women at gestational week 18–22

Characteristic	
Age (years)	28.7 (4.3)
Prepregnancy BMI (kg/m^2)	23.8 (3.9)
Educational level	
College/university	209 (75.5 %)
Primary school, high school, or other	68 (24.5 %)
Marital status	
Married or cohabitant	265 (95.7 %)
Single	12 (4.3 %)
Smoking prepregnancy	
Yes	70 (25.3 %)
Smoking during present pregnancy	
Yes	14 (5.1 %)

Means with SD, numbers with percentages, n=277

between the 277 who completed the study and the 23 that did not.

Table 3 shows mean differences in VRP, PFM strength, and endurance at midpregnancy in women with and without acute cesarean section, prolonged second stage of labor, instrumental vaginal delivery (vacuum and forceps), third- and fourth-degree perineal tear, and episiotomy. Women with prolonged second stage of labor had statistically significantly higher resting pressure at midpregnancy (p<0.01). VRP did not affect any other delivery outcome. No statistically significant differences in PFM strength or endurance were found for any of the delivery variables (Table 4).

Table 2 Description of labor and delivery variables of the study population

Variable	
Normal vaginal delivery	193 (69.7 %)
Cesarean section	39 (14.1 %)
Elective	10 (3.6 %)
Acute	29 (10.9 %)
Induction	52 (18.8 %)
Epidural	112 (40.4 %)
Instrumental vaginal delivery	
Vacuum	41 (14.84 %)
Forceps	4 (1.4 %)
Episiotomy	73 (26.4 %)
Perineal tear	
No tear	164 (59.2 %)
1st-degree	37 (13.4 %)
2nd-degree	67 (24.2 %)
3rd- and 4th-degree	9 (3.3 %)
Second stage of labor (min)	71.7 (53.5)
≤2 h	202 (72.9 %)
>2 h	38 (13.7 %)
Mean weight of baby (g)	3501 (509.0)
Mean head circumference (cm)	34.4 (5.0)

Numbers with percentages, means with SD, n=277

Table 5 shows cOR and aOR for VRP, MVC, and endurance and acute cesarean section, instrumental vaginal delivery, episiotomy, third- or fourth-degree perineal tear, and second stage of labor. cOR and aOR showed a significant association only between midpregnancy VRP and prolonged second stage of labor.

Discussion

Main findings

In the present study of nulliparous pregnant women, midpregnancy VRP was significantly associated with prolonged second stage, but none of the other delivery outcomes, while PFM strength and endurance did not affect the rate of acute cesarean section, prolonged second stage, instrumental vaginal delivery, episiotomy, and third- and fourth-degree perineal tear.

Strengths and limitations

The strengths of the present study include the large sample size, minimal losses to follow-up, PFM assessment using a method shown to be reliable and valid [9, 10], and standardized delivery outcome ascertainment by clinicians unaware of the PFM variables. A limitation of the study is the low numbers of acute cesarean section and third- or fourth-degree tear that, although clinically desirable, may influence our ability to detect differences (type II error). The rate of cesarean section and third- or fourth-degree tears in this cohort of primiparous women is comparable to the general birth population at our hospital, indicating that the results from this study are generalizable outside the study sample. Another limitation is that the women were examined at midpregnancy and not closer to delivery. Elenskaia et al. [16] found a significant increase in resting pressure and PFM strength in nulliparous pregnant women measured in gestational week 21 (range 15–28) and week 36 (range 31–39). However, they did not investigate how PFM variables influenced delivery outcomes, and the effect of resting pressure and PFM strength in late pregnancy therefore remains unknown.

Interpretation

The results showing that PFM strength and endurance did not influence delivery outcome support findings from three

Table 3 VRP, PFM strength, and endurance in women with and without acute cesarean section (CS), prolonged second stage of labor (>120 min), episiotomy, instrumental vaginal delivery (IVD), and 3rd- and 4th-degree perineal tear

	VRP (cmH_2O)	PFM strength/MVC (cmH_2O)	PFM endurance (cmH_2O -10 s)
Acute CS			
Yes	43.8 (12.6)	35.3 (18.3)	250.9 (134.2)
No	42.2 (9.1)	35.3 (18.7)	137.5 (9.9)
	p=0.53	p=0.15	p=0.79
Prolonged 2nd stage			
Yes	46.6 (8.8)	39.7 (16.6)	273.9 (114.4)
No	42.2 (9.3)	34.9 (18.7)	240.9 (139.2)
	p=0.01	p=0.13	p=0.17
Episiotomy			
Yes	42.2 (9.3)	34.8 (17.3)	246.5 (129.1)
No	43.1 (9.7)	35.4 (18.7)	243.7 (137.3)
	p=0.47	p=0.83	p=0.88
IVD			
Yes	44.8 (8.7)	34.8 (16.8)	243.3 (126.1)
No	42.2 (9.2)	35.3 (18.7)	243 .8 (137.5)
	p=0.10	p=0.86	p=0.99
3rd- and 4th-degree perineal tear			
Yes	46.9 (7.6)	34.3 (15.5)	257.7 (124.8)
No	42.7 (9.6)	35.3 (18.4)	244.0 (135.4)
	p=0.20	p=0.87	p=0.77

Mean with SD

previous randomized controlled trials in which there was no deleterious impact on variables between women assigned to PFMT or controls [5, 6, 17]. In one study fewer had deliveries with prolonged second stage in the PFM training group and there were no differences in operative vaginal delivery, episiotomy, third- or fourth-degree tears, epidural analgesia, or oxytocin augmentation [5]. However, there was a statistically significant difference between comparison groups in gestational age, weight of baby, and head circumference between the training and control groups, and these factors were not controlled for. In the present study we controlled for maternal age, prepregnancy BMI, induction, epidural, birth weight, and head circumference, and none of these factors influenced the results. In addition, other studies included no objective measurements of VRP, PFM strength, and endurance; report of training participation cannot replace data on actual PFM variables.

Our results showed that a higher VRP at midpregnancy was significantly associated with prolonged second stage of labor, and this association was significant also when adjusting for known confounding factors. However, both cOR and aOR for the association were low (1.051 for adjusted), and it can be argued that this is not clinically relevant. PFM strength and endurance may be considered proxies for PFM thickness as there are some correlations between these factors [18, 19]. We have deliberately used the term “vaginal resting pressure” rather

Table 4 Difference in VRP, PFM strength (MVC), and endurance at mean gestational week 20.8 (± 1.4) comparing women with and without acute cesarean section, numbers with prolonged second stage of labor, episiotomy, instrumental vaginal delivery (vacuum and forceps), and 3rd- and 4th-degree perineal tear

	VRP (cmH_2O)	PFM strength/MVC (cmH_2O)	PFM endurance (cmH_2O -10 s)
Acute cesarean section (yes/no)	1.6 (−3.4, 6.5)	0.2 (−7.3, 7.3)	7.2 (−46.6, 61.0)
Prolonged 2nd stage (yes/no) 120 min	4.4 (1.2, 7.6)	4.9 (−1.5, 11.3)	33.1 (−14.2, 80.3)
Episiotomy (yes/no)	−1.0 (−3.5, 1.6)	−0.5 (−5.5, 4.4)	2.8 (−33.7, 39.4)
Instrumental vaginal delivery (yes/no)	−2.5 (−5.5 ,0.4)	0.5 (−5.4, 6.5)	0.4 (−43.8, 44.6)
3rd- and 4th-degree perineal tear (yes/no)	4.2 (−2.2, 10.6)	−1.0 (−13.2, 11.2)	13.7 (−77.0, 103.8)

Mean differences with 95% CI, n=267 (women with elective cesarean section excluded)

Table 5 VRP, PFM strength (MVC), and muscle endurance in women with or without acute cesarean section, instrumental vaginal delivery, 3rd- and 4th-degree perineal tear, prolonged second stage of labor, and episiotomy

		Acute cesarean section	Instrumental vaginal delivery	Episiotomy	3rd- or 4th-degree perineal tear	Second stage>120 min
PFM strength/MVC	cOR (95 % CI)	1.000 (0.979–1.021)	1.002 (0.984–1.020)	0.998 (0.984–1.013)	0.997 (0.961–1.034)	1.014 (0.996–1.033)
	p value	0.995	0.857	0.833	0.871	0.138
	aOR[a] (95 % CI)	1.003 (0.980–1.026)	1.007 (0.998–1.027)	0.997 (0.982–1.012)	0.995 (0.958–1.034)	1.006 (0.986–1.026)
	p value	0.801	0.444	0.696	0.816	0.548
Endurance	cOR (95 % CI)	1.000 (0.997–1.002)	1.000 (0.998–1.002)	1.000 (0.998–1.002)	1.001 (0.996–1.006)	1.002 (0.999–1.004)
	p value	0.792	0.985	0.878	0.765	0.171
	aOR[a] (95 % CI)	1.000 (0.997–1.003)	1.001 (0.998–1.003)	1.000 (0.998–1.002)	1.001 (0.996–1.006)	1.001 (0.998–1.004)
	p value	0.960	0.522	0.987	0.713	0.531
VRP	cOR (95 % CI)	0.984 (0.947–1.023)	0.971 (0.939–1.005)	0.989 (0.961–1.018)	1.040 (0.980–1.105)	1.048 (1.011–1.086)
	p value	0.418	0.097	0.464	0.197	0.010
	aOR[a] (95 % CI)	0.991 (0.950–1.035)	0.975 (0.940–1.011)	0.984 (0.956–1.014)	1.027 (0.967–1.091)	1.051 (1.010–1.093)
	p value	0.687	0.167	0.298	0.381	0.013

n=267 (elective cesarean section excluded)

cOR crude odds ratio, *aOR* adjusted odds ratio, *CI* confidence interval

[a] Adjusted for maternal age, prepregnancy BMI, induction, epidural, birth weight, and head circumference

than "pelvic floor muscle resting pressure" as other structures, such as fat or viscera, might contribute to the measured pressure obtained. However, our population contained few obese women so it is unlikely that fat played a sizable role in the measured pressure. Resting pressure may be considered a more direct measure of tightness of the PFM as this variable reflects the resting condition without any voluntary contraction. Indeed, there is a correlation between VRP and levator hiatus (LH) area, but PFM strength and VRP explained only 26.4 % of the variance in LH area after controlling for age, parity, BMI, and socioeconomic status in women with pelvic organ prolapse [19]. To date very few studies have analyzed delivery outcomes according to VRP. Aran et al. [20] found that in 88 women who all had labor induction with oxytocin women who failed labor and subsequently underwent cesarean section had significantly higher resting pressure and MVC compared to those who had vaginal delivery. PFM variables were measured just before labor induction. There were no differences in maternal age, BMI, and neonatal weight between the groups. This, however, was a selected group, as they all had induction, and the results cannot be generalized to other populations.

The widespread belief that a tight pelvic floor may obstruct labor and birth was the motivation for the development of a birth trainer to stretch the perineum, vagina, and PFM with the goal of preventing major perineal and PFM injuries [21]. However, a randomized controlled trial of 146 pregnant women randomized to either stretching of the PFM or no stretching found no statistically significant differences in delivery mode, length of second stage, episiotomy, or perineal tear [21]. The authors consider the trial a pilot study and intend to increase their number of participants to test this hypothesis in a larger sample of pregnant women.

The present study found that PFM strength and endurance did not influence delivery outcome. Hence, women's voluntary ability to contract as close to maximum as possible and their ability to hold the PFM contraction had no negative effect on childbirth. Antenatal PFMT significantly increases PFM strength [22]. However, we have not been able to find any data on the effect of PFMT on VRP [1]. Our results indicate that midpregnancy VRP may be a risk factor for prolonged second stage of labor. However, the clinical relevance of this finding is limited as the difference in VRP between women with and without prolonged second stage was only 4.4 cmH_2O. We suggest that VRP may be an important factor to measure in future studies on the effect of peripartum PFMT on health variables in mother and child.

Conclusions

This study indicates that midpregnancy VRP may be associated with prolonged second stage of labor. However, neither VRP nor PFM strength or endurance was associated with operative delivery or perineal tears, and the clinical relevance of such a small risk estimate can be discussed. Strong PFM are not disadvantageous for vaginal delivery. More research on VRP is warranted.

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Conflicts of interest None.

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