GENERAL GYNECOLOGY

Impact of childbirth and mode of delivery on vaginal resting pressure and on pelvic floor muscle strength and endurance

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OBJECTIVE: We sought to study impact of delivery mode on vaginal resting pressure (VRP) and on pelvic floor muscle (PFM) strength and endurance, and whether these measurements differed in women with and without urinary incontinence.

STUDY DESIGN: We conducted a cohort study following 277 nulliparous women from midpregnancy to 6 weeks postpartum. Manometer was used for PFM measurements; differences were analyzed by *t* test (within groups) and analysis of variance (between groups).

RESULTS: Only VRP changed significantly (10% reduction, $P = .001$) after emergency cesarean section. After normal and instrumental vaginal delivery, VRP was reduced by 29% and 30%; PFM strength by 54% and 66%; and endurance by 53% and 65%, respectively. Significant differences for all PFM measures ($P < .001$) were found when comparing cesarean vs normal and instrumental vaginal delivery, respectively. Urinary continent women at both time points had significantly higher PFM strength and endurance than incontinent counterparts ($P < .05$).

CONCLUSION: Pronounced reductions in VRP and in PFM strength and endurance were found after vaginal delivery. Continent women were stronger than incontinent counterparts.

Key words: mode of delivery, pelvic floor muscle strength and endurance, pregnancy and childbirth, urinary incontinence, vaginal resting pressure

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The pelvic floor muscles (PFM) play a significant role in the continence control system and pelvic organ support.[1] The most established risk factor for pelvic floor dysfunction and weakening of the PFM is vaginal delivery.[2-9] During vaginal childbirth, PFM, nerves, and connective tissue are forcibly stretched, compressed, and bruised. Neurophysiologic studies have shown that vaginal deliveries cause partial denervation of the pelvic floor striated muscles in most women,[8-10] whereas imaging studies have shown major defect of the most medial part of the PFM, the pubococcygeus muscle, within the range 13–36% among primiparous women delivering vaginally.[2,11,12] Hence, it is likely that the impact of vaginal childbirth may lead to reduced vaginal resting pressure (VRP) and reduced PFM strength and endurance, and that cesarean section (CS) may protect the PFM.

To date there is a paucity of knowledge regarding the change in VRP and in PFM strength and endurance from pregnancy to postpartum. Studies assessing change in PFM strength from pregnancy to shortly after childbirth (3 days to 12 weeks postpartum) in relation to mode of delivery have used either digital palpation,[13-15] manometry,[14,16-18] or electromyography.[13] Except for the studies of Caroci et al[14] and Meyer et al[18] counting 226 and 149 nulliparous women, respectively, the sample sizes of the above-cited studies were small, ranging from 20–75 participants. This leaves very few women in each group of delivery mode. Results from above-cited studies are conflicting and none of the published studies addressed change in VRP when comparing modes of delivery. The cohort study by Elenskaia et al,[19] including 182 nulliparous women during the second trimester, was not included as a comparable study as they discriminate between delivery modes only at their last study visit, taking place 12 months postpartum.

Pregnancy and childbirth are considered main etiological factors in the development of urinary incontinence (UI).[20] UI in nulliparous women before and after delivery has been associated with reduced PFM strength[15,18,21] and endurance.[15,21] However, only 2 of these studies[15,18] had a prospective design, following up 20 and 149 nulliparous women from pregnancy to after childbirth, respectively.

The aims of the present study were to: (1) study impact of childbirth and mode of delivery on PFM function in terms of ability to contract, VRP, and PFM strength and endurance from midpregnancy to 6 weeks postpartum; and (2) investigate changes in VRP and in PFM strength and endurance from midpreg-

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nancy to 6 weeks postpartum in women with and without UI.

MATERIALS AND METHODS

This is a prospective cohort study following 300 nulliparous pregnant women from midpregnancy to 6 weeks postpartum. All nulliparous women scheduled for delivery at Akershus University Hospital, Norway from January 2010 through April 2011 were invited to participate, and they were recruited in connection with the routine ultrasound examination in gestational week 18–22 (midpregnancy).

Nulliparous women with a singleton pregnancy who could speak and understand Scandinavian languages were included. Women with a prior abortion after gestational week 16 were excluded. To attend the study visit at 6 weeks postpartum, the women had to give birth after gestational week 32. Women with stillbirth were excluded. The time point 6 weeks postpartum was chosen on the basis of convenience for the participating women, as it could be combined with their routine postpartum appointment.

Demographic data were collected through an electronic questionnaire in conjunction with participants' first clinical visit, which was taking place shortly after routine ultrasound examination at gestational week 18–22. Data on delivery mode and other obstetric variables were collected from the hospital's electronic medical records.

PFM measurements

During the first visit, participants were taught how to perform a correct PFM contraction. PFM contraction without any movement of the pelvis or visible contraction of the gluteal, hip, or abdominal muscles was emphasized as described in Bø et al.[22] All examinations were performed with the participant in a standardized supine crook lying position. Correct contraction was assessed on the basis of palpation and observation and defined as inward movement and squeeze around the pelvic floor openings.[22,23] VRP and strength and endurance of the PFM were measured by using an air-filled vaginal balloon connected to a high-precision pressure transducer (Camtech AS, Sandvika, Norway). The middle of the balloon was positioned 3.5 cm inside the introitus.[24] PFM strength was calculated as the mean of 3 maximal voluntary contractions. The method has been found to be reliable and valid if used with simultaneous observation of inward movement of the perineum/catheter during the contraction.[22,25] VRP was measured with the balloon positioned in the vagina without any voluntary PFM activity. PFM endurance was defined as a sustained maximal contraction, and was quantified during the first 10 seconds as the area below the measurement curve (integral calculation).[26] The balloon was set to 0 cm H_2O for each subject before it was placed into the vagina. Changes (Δ) in VRP and in PFM strength and endurance from midpregnancy (visit 1) to 6 weeks postpartum (visit 2) were recorded as ΔVRP, ΔPMF strength, and ΔPFM endurance. The 2 assessors were blinded for delivery data at the second visit. To minimize biases in assessment and manometer measurement, the assessors (both physiotherapists) were trained ahead of the study and a rigorous protocol in standards of procedures was kept.

UI

International Consultation on Incontinence Questionnaire (ICIQ) UI Short Form (SF) was included in the electronic questionnaire. ICIQ UI SF has been shown to have good construct validity, acceptable convergent validity, and good reliability.[27] Women were defined as continent when answering "never" to the question: "How often do you leak urine?" (ICIQ UI SF).

Statistical analysis

Statistical analysis was performed using software (version 15; SPSS, Inc, Chicago, IL). Background and descriptive variables are presented as frequencies with percentages or means with SD. Changes from midpregnancy to 6 weeks postpartum within group regarding VRP and PFM strength and endurance were analyzed using Paired-sample *t* test for normally distributed data and Wilcoxon signed rank test for nonnormally distributed data. Differences between delivery modes and differences between incontinent and continent women were analyzed by using 1-way between-groups analysis of variance if data qualified for a normal distribution. If not Kruskal-Wallis test was used. Standard multiple linear regression was used to analyze the role of demographic and obstetric variables on the change of PFM measurements. P values $< .05$ were considered significant.

This study is part of a prospective cohort. The sample size of 300 was a result of power calculation on change in hiatal dimensions of the levator ani muscle from pregnancy to postpartum (using 3-/4-dimensional ultrasound), and not VRP and PFM strength and endurance.

Institutional review board

The study was approved by the Regional Medical Ethics Committee (2009/170) and Norwegian Social Science Data Services (2799026), and registered at ClinicalTrials.gov (NCT01045135). All subjects gave written informed consent before entering the study.

RESULTS

Three hundred nulliparous pregnant women were included at midpregnancy and 277 were seen again as primiparous at 6 weeks postpartum. Of the 23 (7.7%) women not attending the clinical examination postpartum, 10 delivered at another hospital, 9 did not want to continue, 3 had a stillbirth, and 1 was excluded due to delivery <32 weeks of gestation. Characteristics of the study sample attending both clinical visits (n = 277) are shown in Table 1. Mean gestational week at the first study visit was 21 (SD 1.4), ranging from gestational week 17–25. After delivery, the mean postpartum week was 6.2 (SD 1.0), ranging from 3–11 weeks postpartum.

Eleven (3.9%) of 277 women did not contract the PFM correctly at midpregnancy. At the visit 6 weeks postpartum 4 of those 11 had learned to contract correctly; 3 had a normal vaginal delivery (NVD) and 1 had CS. Seven of those 11 were still unable to perform a correct contraction; 6 had NVD and 1 had CS. Further, 5 women contracting the PFM correctly at midpregnancy had lost the

TABLE 1
Characteristics of nulliparous women included at gestational week 21 (n = 277)

Characteristic	Value
Age, y	28.7 (4.3)
Prepregnancy BMI, kg/m^2	23.8 (3.9)
Education level	
College or 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	
No	207 (74.7%)
Yes	70 (25.3%)

Continuous variables given as mean with SD. Categorical variables given as numbers with percentages.
BMI, body mass index.

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ability to contract after delivery; 2 had a NVD and 3 had an instrumental vaginal delivery (IVD). This leaves 12 of 277 women (4.3%) not contracting correctly 6 weeks postpartum.

Of the 277 women 69.7% had NVD, 16.2% had IVD (41 with vacuum, 4 with forceps), and 14.1% delivered by CS (29 emergency, 10 elective). The women having elective CS were excluded from further analysis (Tables 2-5). Five of the 29 women having emergency CS were in second stage of labor before CS was performed. Indication was fetal distress in 1 case and protracted total second stage in the remaining 4 cases.[28]

Measurements on VRP and PFM strength and endurance within delivery mode groups are presented in Table 2 and between delivery modes in Table 3. Within the CS group a 10% reduction in VRP, 12% reduction in PFM strength, and 11% reduction in endurance was found, however change was statistically significant for resting pressure only (Table 2). Within-groups changes for both NVD and IVD were highly significant for all PFM measures ($P < .001$) (Table 2).

Mean differences in change from midpregnancy to 6 weeks postpartum were significant for all PFM measurements when comparing CS vs NVD and CS vs IVD (Table 3). VRP was reduced by 29% in the NVD group and by 30% in the IVD group: respectively 2.8 and 3.2 times more than the reduction found in the CS group. For the same comparison PFM strength was reduced by 54% (NVD) and 66% (IVD): respectively 4.3 and 5.2 times more than the CS group. Finally, PFM endurance was reduced by 53% (NVD) and 65% (IVD): respectively 4.5 and 5.5 times more than the CS group. When comparing women with NVD and IVD, there were no significant differences in changes from midpregnancy to 6 weeks postpartum in VRP or in PFM strength or endurance (Table 3).

Table 4 shows that prepregnancy body mass index influenced change in resting pressure from midpregnancy to 6 weeks postpartum, whereas PFM strength and endurance were influenced by a total second stage lasting >60 minutes.

Thirty-six percent (94 of 264) reported UI at midpregnancy, and 40% (106 of 264) at 6 weeks postpartum. Of the 94 women having UI at midpregnancy, 58 still had UI 6 weeks postpartum, whereas 36 became continent (Table 5). Of the 170 women having no UI at midpregnancy, 122 were still continent at 6 weeks postpartum, whereas 48 reported de novo UI. Women with no UI at both time points had significantly higher PFM strength and endurance than their incontinent counterparts (Table 5). No significant differences were found when comparing women with de novo UI postpartum and women with persistent UI postpartum (UI at both time points) and continent women (no UI both time points), respectively (Table 5). The 4 comparison groups did not differ in age, prepregnancy body mass index (1-way analysis of variance), or antenatal PFM training (PFMT) ≥3 times per week (χ^2 test for independence).

COMMENT

Analyzing the data for different delivery modes, we found no changes in PFM strength or endurance for the CS group, but a significant and pronounced reduction in all PFM measurements for vagi-

TABLE 2
Delivery modes and pelvic floor muscle function; within-group differences (n = 267)

	CS (n = 29)				NVD (n = 193)				IVD (n = 45)			
Variable PFM measures	Gestational wk 21, mean (SD)	6 wk postpartum, mean (SD)	Mean difference (95% CI)	P value	Gestational wk 21, mean (SD)	6 wk postpartum, mean (SD)	Mean difference (95% CI)	P value	Gestational wk 21, mean (SD)	6 wk postpartum, mean (SD)	Mean difference (95% CI)	P value
VRP, cmH$_2$O	43.8 (12.6)	39.5 (12.1)	4.3 (1.6–7.0)	.003	42.2 (9.2)	30.1 (6.8)	12.2 (11.0–13.3)	< .001	44.8 (8.7)	31.1 (9.6)	13.6 (11.4–15.9)	< .001
PFM strength, cmH$_2$O	35.3 (18.3)	30.9 (16.0)	4.4 (−0.5 to 9.4)	.077	35.3 (18.7)	16.4 (12.3)	18.9 (17.0–20.8)	< .001	34.8 (16.8)	11.8 (8.3)	22.9 (18.9–27.0)	< .001
PFM endurance, cmH$_2$Osec	250.9 (134.2)	222.3 (140.0)	28.6 (−19.7 to 76.9)	.236	243.8 (137.5)	114.7 (85.7)	129.1 (113.7–144.4)	< .001	243.3 (126.1)	86.0 (68.4)	157.3 (126.9–187.7)	< .001

Paired-sample *t* test. Women with elective CS (n = 10) not included.
CI, confidence interval; *CS*, cesarean section (emergency only); *IVD*, instrumental vaginal delivery (vacuum and forceps); *NVD*, normal vaginal delivery; *PFM*, pelvic floor muscle; *VRP*, vaginal resting pressure.

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TABLE 3
Delivery modes and pelvic floor muscle function; between-group differences (n = 267)

Variable PFM measurements	CS (n = 29) vs NVD (n = 193)		CS (n = 29) vs IVD (n = 45)		NVD (n = 193) vs IVD (n = 45)	
	Mean difference (95% CI)	*P* value	Mean difference (95% CI)	*P* value	Mean difference (95% CI)	*P* value
VRP gestational wk 21, cmH_2O	1.6 (−2.9 to 6.0)	.689	−1.0 (−6.3 to 4.4)	.906	−2.5 (−6.2 to 1.2)	.247
VRP 6 wk postpartum, cmH_2O	9.4 (5.7–13.2)	< .001	8.4 (3.9–12.9)	< .001	−1.0 (−4.2 to 2.1)	.718
ΔVRP, cmH_2O	−7.9 (−11.7 to −4.1)	< .001	−9.4 (−13.9 to −4.8)	< .001	−1.5 (−4.6 to 1.7)	.505
PFM strength gestational wk 21, cmH_2O	0.0 (−8.6 to 8.6)	1.000	0.6 (−9.7 to 10.9)	.991	0.5 (−6.6 to 7.7)	.982
PFM strength 6 wk postpartum, cmH_2O	14.5 (8.7–20.2)	< .001	19.1 (12.2–25.9)	< .001	4.6 (−0.2 to 9.4)	.061
ΔPFM strength, cmH_2O	−14.5 (−20.7 to −8.2)	< .001	−18.5 (−26.0 to −11.0)	< .001	−4.0 (−9.2 to 1.2)	.160
PFM endurance gestational wk 21, cmH_2Osec	7.2 (−56.3 to 70.7)	.962	7.6 (−68.4 to 83.6)	.970	0.4 (−52.4 to 53.2)	1.000
PFM endurance 6 wk postpartum, cmH_2Osec	107.7 (65.2–150.2)	< .001	136.3 (85.5–187.2)	< .001	28.6 (−6.7 to 64.0)	.138
ΔPFM endurance, cmH_2Osec	−100.5 (−151.8 to −49.2)	< .001	−128.7 (−190.0 to −67.4)	< .001	−28.2 (−70.8 to 14.4)	.265

One-way between-groups analysis of variance. Women with elective CS (n = 10) not included. PFM strength is reported as the mean of 3 maximal voluntary contractions. PFM endurance is reported after 1 attempt of sustained maximal contraction quantified during 10 seconds.

CI, confidence interval; *CS*, cesarean section (emergency only); *IVD*, instrumental vaginal delivery (vacuum and forceps); *NVD*, normal vaginal delivery; *PFM*, pelvic floor muscle; *VRP*, vaginal resting pressure; Δ, change between gestational week 21 and 6 weeks postpartum.

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nal delivery modes (NVD and IVD). Women who were continent both at midpregnancy and 6 weeks postpartum had significantly higher PFM strength and endurance than their incontinent counterparts. Multivariate analysis showed that delivery mode was the most important factor for change in PFM variables.

Strengths of the present study were the number of participants followed up from pregnancy to after childbirth, few losses to follow-up (7.7%), and that the participants had their clinical examination within a low variation of time, both at midpregnancy and 6 weeks postpartum. To our knowledge this is one of the largest cohort studies presenting clinical data on VRP and on PFM strength and endurance in women delivering their first child. An added strength is the use of a high-precision manometer to evaluate change in PFM function, a method found to be responsive, reliable, and valid.[22,25] Further, the assessors were blinded for delivery mode. A limitation is the low number of women with CS (n = 29) and instrumental assisted deliveries (n = 45). This is also a challenge for comparable studies, having a cesarean group sizes ranging from 5–37 women.[13-18] Another limitation could be that the women were examined in midpregnancy but not again closer to delivery. A possible contribution of changes late in pregnancy can therefore not be taken into account. However, we found no changes in PFM strength and endurance within the CS group, indicating that the impact of late pregnancy events on outcome measures seems unlikely. A lack of priori power calculation is a weakness and might weaken this statement as the CS group is small. However, according to the study by Sigurdardottir et al,[17] a group size of 8 women was needed to detect changes in PFM strength associated with childbirth.

Our study sample was comparable to the total population of nulliparous women (n = 2621) scheduled for delivery at Akershus University Hospital during the inclusion period with respect to age (mean of 28.7 and 28.4 years, respectively) and being married/cohabitant (95.7% and 92.7%, respectively). Further, the CS rate was similar: 14.1% in our study sample and 16.9% in the total nulliparous population at our hospital. However, our study sample differed in educational status as 75.5% of our participants had higher education (college/university), compared to 50.8% in the total population of nulliparous women. The latter may be linked to the inclusion criterion of being able to speak and understand Scandinavian languages.

At both clinical visits, examination by palpation and observation showed that 4% were unable to contract their PFM correctly, which is in line with the study by Mørkved et al,[21] but might be considered low when compared to studies reporting ≥30%.[23,29-31] However, direct comparison from study to study is difficult due to heterogeneity in study samples and the degree of instruction on how to contract the PFM correctly before the final assessment. In this study and the study from Mørkved et al,[21] the registration of ability to contract was done after

TABLE 4
Role of demographic and obstetric variables on change in pelvic floor muscle function (n = 267)

	Factor					
	ΔVRP, cmH_2O		ΔPFM strength, cmH_2O		ΔPFM endurance, cmH_2Osec	
Variable	B coefficient (95% CI)	*P* value	B coefficient (95% CI)	*P* value	B coefficient (95% CI)	*P* value
CS[a]	−8.0 (−11.3 to −4.6)	< .001	−16.1 (−21.6 to −10.6)	< .001	−111.5 (−156.6 to −66.5)	< .001
IVD[a]	1.2 (−1.6 to 4.1)	.403	1.4 (−3.3 to 6.1)	.546	9.6 (−29.1 to 48.2)	.626
Age	0.1 (−0.1 to 0.4)	.270	0.229 (−0.2 to 0.6)	.251	1.5 (−1.7 to 4.7)	.366
Prepregnancy BMI	−0.5 (−0.7 to −0.2)	.001	−0.4 (−0.8 to 0.1)	.101	−3.6 (−7.2 to −0.2)	.049
Length of total second stage >60 min	1.7 (−0.4 to 3.9)	.117	6.9 (3.3–10.5)	< .001	52.5 (23.0–82.0)	.001
Epidural	−0.2 (−2.3 to 2.00)	.886	−0.8 (−4.3 to 2.8)	.668	−12.0 (−41.3 to 17.3)	.422
Fetal birthweight	0.0 (0.0–0.0)	.546	0.0 (0.0–0.0)	.694	0.0 (−0.1 to 0.0)	.478
Head circumference	−0.8 (−1.6 to 0.0)	.062	0.6 (−0.8 to 2.0)	.399	6.7 (−4.6 to 18.1)	.244

Standard multiple linear regression. Women with elective CS (n = 10) not included.
BMI, body mass index; *CI*, confidence interval; *CS*, cesarean section (emergency only); *IVD*, instrumental vaginal delivery (vacuum and forceps); *PFM*, pelvic floor muscle; *VRP*, vaginal resting pressure; Δ, change.
[a] Normal vaginal delivery as reference.
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several attempts and guidance by the physiotherapist during vaginal palpation.

PFM and innervating nerves are forcibly stretched during vaginal deliveries. Muscle fibers might be stretched up to 3 times their resting length as the fetal head is crowning,[32] and nerves innervating the levator ani might exhibit a strain of 35%.[33] It is therefore not surprising that measurements on VRP and on PFM strength and endurance 6 weeks postpartum were significantly influenced by mode of delivery, with vaginal delivery as the strongest predictor. Our results showing that PFM strength was not influenced by CS, but significantly influenced and pronounced by vaginal delivery, are in contrast to the findings by

TABLE 5
Urinary continence and pelvic floor muscle function; between-group differences (n = 264)

PFM measure	1. No UI[a] at any time point (n = 122)	2. No UI[a] gestational wk 21 but UI 6 wk postpartum (n = 48)	3. UI gestational wk 21 but no UI[a] 6 wk postpartum (n = 36)	4. UI at both time points (n = 58)	*P* value
VRP gestational wk 21, cmH_2O	44.0 (10.3)	42.4 (7.9)	42.0 (8.2)	41.2 (10.1)	> .05 (all comparisons)
VRP 6 wk postpartum, cmH_2O	32.6 (8.7)	29.9 (6.4)	31.1 (8.3)	29.8 (9.4)	> .05 (all comparisons)
ΔVRP, cmH_2O	11.4 (9.0)	12.6 (7.2)	10.9 (8.1)	11.4 (8.7)	> .05 (all comparisons)
PFM strength gestational wk 21, cmH_2O	38.2 (17.0)	36.4 (21.0)	34.6 (19.4)	28.8 (16.2)	.006 (1 vs 4) > .05 (all other comparisons)
PFM strength 6 wk postpartum, cmH_2O	19.3 (14.8)	15.8 (11.5)	20.0 (13.0)	12.5 (9.4)	.006 (1 vs 4) .032 (3 vs 4) > .05 (all other comparisons)
ΔPFM strength, cmH_2O	18.9 (14.8)	20.6 (14.4)	14.6 (13.7)	16.3 (12.8)	> .055 (all comparisons)
PFM endurance gestational wk 21, cmH_2Osec	264.5 (121.9)	251.9 (158.6)	245.9 (147.2)	199.6 (123.3)	.013 (1 vs 4) > .05 (all other comparisons)
PFM endurance 6 wk postpartum, cmH_2Osec	135.0 (105.7)	117.0 (96.3)	138.5 (93.7)	86.9 (73.6)	.010 (1 vs 4) > .05 (all other comparisons)
ΔPFM endurance, cmH_2Osec	129.5 (120.5)	134.9 (113.4)	107.4 (122.4)	112.7 (96.8)	> .05 (all comparisons)

One-way between-groups analysis of variance: mean with SD, statistical difference between groups given as *P* value. Women with elective cesarean section (n = 10) not included; additional 3 participants had missing data on no UI/UI, total n = 264. PFM strength is reported as the mean of 3 maximal voluntary contractions. PFM endurance is reported after 1 attempt of sustained maximal contraction quantified during 10 seconds.
PFM, pelvic floor muscle; *UI*, urinary incontinence; *VRP*, vaginal resting pressure; Δ, change between gestational week 21 and 6 weeks postpartum.
[a] Answered "never" to question "How often do you leak urine?" (question 3; International Consultation on Incontinence Questionnaire UI Short Form).
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Caroci at al,[14] but in line with findings in other comparable studies using manometry.[16-18] Sigurdardottir et al,[17] following up 36 nulliparous women from midpregnancy to 6-12 weeks postpartum, found a reduction in PFM strength by 49% in the NVD group and 64% in the IVD group. Peschers et al[16] found a 35% decline in PFM strength from late pregnancy to 6-10 weeks postpartum in primiparous women delivering vaginally (n = 25), but for multiparous women delivering vaginally (n = 20) they found that PFM strength at 6-10 weeks postpartum returned to strength measurements from late pregnancy. Finally, Meyer et al[18] following up 149 nulliparous women from pregnancy to 9 weeks postpartum found a decline of 14% in the NVD group (n = 91) and 35% in the IVD group (n = 25, all forceps deliveries).

Difference in VRP and in PFM strength and endurance from pregnancy to after childbirth can be influenced by a testing effect obtained from first to second assessment. To minimize this effect we emphasized thorough instruction on how to contract correctly before the final assessment at the first clinical visit. How this was handled in the above-mentioned studies[16-18] we do not know, but testing effect might be a factor explaining variance of change in PFM measurements seen in the different studies. Additionally, variance in time point of the first assessment (ie, midpregnancy or late pregnancy) and further length of recovery after childbirth before the second assessment may influence change measurements. This assumption is supported by Peschers et al[16] as they also measured PFM strength shortly after delivery (2-8 days) and found a significant improvement from this time point to 6-10 weeks postpartum.

In contrast to our results, Sigurdardottir et al[17] reported no significant difference in VRP when comparing vaginal deliveries with CS. A possible explanation for divergent findings might be a lack of statistical power in the study by Sigurdardottir et al,[17] as their study sample only counted 5 women with CS.

No significant differences in change from midpregnancy to 6 weeks postpartum were found when comparing NVD vs IVD. This was unexpected since IVD and the use of forceps have been shown to be associated with levator trauma.[12,34] A plausible explanation for this nonsignificant difference might be that only 4 of the 45 instrumental deliveries in our study were forceps assisted. Interestingly, Shek and Dietz[35] found that vacuum-assisted delivery had less impact on the PFM when compared to NVD.

How well VRP and PFM strength and endurance recover in the postpartum year is of great interest, and further, whether PFMT of high quality would add more than natural recovery alone. To our knowledge, Elenskaia et al[19] conducted to date the only study with long-term follow-up. They found that PFM strength recovered completely at 1 year postpartum in both primiparous and multiparous women irrespective of delivery mode. Additional studies are needed to see whether their findings can be confirmed or not.

Change in VRP and in PFM strength and endurance from midpregnancy to 6 weeks postpartum showed no significant differences for any of the PFM measurements when comparing women with and without UI. However, our results showed that women who were continent both at midpregnancy and 6 weeks postpartum had significantly higher PFM strength and endurance than their incontinent counterparts. Our findings are supported by Mørkved et al[21] and Sampselle.[15] Our results indicate that PFM strength and endurance are of importance for staying continent during pregnancy and after childbirth. Even though PFM strength and endurance are reduced just as much for continent women as for women with UI, continent women at midpregnancy seem to be better off at 6 weeks because they have a better starting point regarding PFM strength and endurance.

The evidence on effect of postpartum PFMT in prevention and treatment of UI is conflicting.[36] Changes in PFM measures in our study do not explain de novo UI, which might be explained by factors not explored in this study such as overall position of the pelvic floor, levator hiatus area, and general descent of the pelvic floor during increase in intraabdominal pressure. However, our results link PFM strength and endurance with UI both at midpregnancy and 6 weeks postpartum, and it seems like women with no UI and higher PFM strength and endurance at midpregnancy can cope better with the pronounced decline in strength and endurance after vaginal delivery. This does address the need of a proper clinical examination of PFM function and pelvic floor dysfunction both during pregnancy and after childbirth.

In addition to a general weakness of the PFM, partly attributable to excessive stretching during childbirth, muscle, peripheral nerve, and connective tissue injuries may play an important role in reduction of PFM function.[7] So far, there is scant knowledge about the association between diagnosed PFM injuries and VRP, PFM strength, and PFM endurance. However, a cross-sectional study[37] on women with pelvic organ prolapse found larger hiatal dimensions both at rest and at maximal contraction among women diagnosed with major PFM defects when compared to women without such muscle defect.

To which degree injured PFM respond to training is still not known, and needs to be tested in a high-quality randomized controlled trial. ■

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