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ORIGINAL ARTICLE

Pelvic floor muscle function before and after first childbirth

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Abstract

Introduction and hypothesis Pregnancy and vaginal delivery are considered to be the main risk factors for development of pelvic floor dysfunction. We hypothesize that; 1) pelvic floor muscle (PFM) strength and endurance is significantly reduced by first delivery in general, and 2) changes in PFM strength and endurance are influenced by mode of delivery.

Methods Prospective repeated measures observational study. Thirty-six women completed the study. PFM function was measured as vaginal squeeze pressure. Paired *t*-test was used to compare PFM function before and after first childbirth for all participants as a group. One-way ANOVA was used to compare changes between different modes of delivery.

Results A significant reduction in PFM strength ($p<0.0001$) and endurance ($p<0.0001$) was found for all participants after first childbirth. The reduction in strength was 20.1 hPa (CI:16.2; 24.1), 31.4 hPa (CI: 7.4; 55.2) 5.2 hPa (CI: −6.6; 17.0) in the normal vaginal, instrumental vaginal and acute cesarean groups, respectively. The difference was significant between normal vaginal and acute cesarean birth ($p=0.028$) and instrumental vaginal and acute cesarean birth ($p=0.003$).

Conclusion PFM strength is significantly reduced after vaginal delivery, both normal and instrumental, 6 to 12 weeks postpartum. Acute cesarean section resulted in significantly less muscle strength reduction.

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Introduction

Pregnancy and vaginal delivery are considered to be the main risk factors in weakening the pelvic floor muscles (PFM) and development of stress urinary incontinence and pelvic organ prolapse in younger women [1–4]. This is considered to be due to damage to fascias, ligaments, muscles and peripheral nerves, all interacting and necessary tissues for pelvic organ support and control of continence mechanism [3, 5].

Muscle and nerve damages to the pelvic floor have been reported to be a consequence of vaginal childbirth [3, 6–8]. Cesarean section performed for obstructed labor or after the onset of labor has been reported to be ineffective in protecting the pelvic floor, especially after a long second stage of labor [3, 9, 10]. The effects of other obstetric factors on the pelvic floor have also been evaluated. The main risk factors for muscular and neurologic damages to the pelvic floor have been identified as; midline episiotomy, the use of forceps, third or fourth degree lacerations, high birth weight, large head circumference and prolonged active second stage of labor. The use of vacuum extraction has been found to be less traumatic to the pelvic floor than the use of forceps [11–13].

To date there are controversies in how, and for how long PFM function is affected by vaginal delivery [3, 7, 14–17]. Few studies have analyzed the results according to types of vaginal delivery but the general consensus is that vaginal delivery reduces strength [3, 7, 17, 18]. No studies have been found that assesses PFM endurance in the puerperium and the influences of different modes of delivery thereon.

In the present study, we hypothesize that; 1) PFM strength and endurance is significantly reduced by first delivery in general, and 2) changes in PFM strength and endurance are influenced by mode of delivery.

Materials and methods

Design

This was a non-blinded, prospective repeated measures observational study assessing changes in PFM function associated with first childbirth. All women signed an informed consent before participation. The study was approved by the Icelandic National Bioethics Committee (ref. number 06–070) and was in accordance with the Helsinki declaration on human experimentation.

Participants

The sample was a non-randomized, convenience sample. Women in their first pregnancy were recruited through the Primary Health Care centers in the capital area of Reykjavik, Iceland. Midwives identified women willing to participate in their first routine antenatal visit at 13th to 16th weeks of gestation. After an ultrasound scan in the 20th week, where a singleton pregnancy was confirmed and without any major anomalies being found, the researcher (TS) contacted the women by phone, and invited them to participate. Other inclusion criteria were: Age ≥18 years, healthy and being able to understand Icelandic or English. Exclusion criteria were high risk [19] and multiple pregnancies, elective cesarean section, ongoing urinary infections or other diseases that could interfere with the participation. The women were evaluated at 20–26 weeks of gestation and at 6 to 12 weeks postpartum. The measurements took place in an outpatient physiotherapy clinic from April 2007 until March 2008 and the participants were followed up with the postpartum measurements until July 2008.

Power calculation

The study of Peschers et al. from 1997 measuring PFM strength before and after childbirth with perineometer was used to estimate changes in PFM strength associated with childbirth. Both mean and standard deviations from the study of pre and post delivery measurements of primiparas were used [7]. With a power of 80%, $p \leq 0.05$ and a correlation of 0.80 between PFM strength during pregnancy and postpartum, 8 participants were needed to detect changes associated with childbirth. If no correlation was found between pre and post delivery measurements, 32 participants were needed [20]. SDs for the differences of pre and post measurements for the groups in the present study were: acute cesarean: 9.47, instrumental: 14.58, normal vaginal: 10.32, and overall SD (all participants): 13.39. Correlation between pre and post measurements was also high: acute cesarean: 0.85, instrumental: 0.80 and normal vaginal: 0.78.

Questionnaires

The women answered 4 repeated questionnaires, covering time from before pregnancy to postpartum; two when they came for PFM measurements during mid-pregnancy (health before pregnancy and health during mid-pregnancy), the third questionnaire (health during last month of pregnancy and first days after delivery) in the first days after delivery, and the fourth questionnaire (health postpartum), was answered during the second PFM measurement postpartum. This was an observational study with no intervention. Women were asked though if they practiced PFM exercises, in all four questionnaires. They were also asked about physical activity and smoking status. Only background variables, i.e. maternal age and BMI, from the questionnaires are addressed here.

Outcome measures

The main outcome measures were changes in PFM strength measured as maximum voluntary contraction (MVC) and endurance measured as the length of a sustained contraction in seconds as well as the ability to contract repeatedly at least 15 times.

Ability to contract the PFM

The participating women were first informed about PFM function and taught how to correctly contract the muscles [5]. They were instructed to focus on the PFM during the tests and to try to avoid co-contraction of outer pelvic muscles such as hip adductors, gluteals and external rotators as much as possible. However, a small visible co-contraction of the abdominal wall was allowed if no movement of the pelvic girdle was observed [21]. They were also asked to breath normally during the measurements. Ability to perform a correct PFM contraction, defined as a squeeze around the urethra, vagina and rectum and an inward (cranial) and forward (ventral) lift of the muscle plate [5] was tested with one finger vaginal palpation and observation of inward movement of the perineal area during a contraction [22, 23].

Strength and endurance

The device used for assessment of PFM strength and endurance was Myomed 932® (Enraf-Nonius, Delft, Netherland). This apparatus measures pressure changes vaginally by means of a cavity probe. Pressure signals can be graphically reproduced with adjustable sensibility and time scales. After insertion of the probe into the vagina, the LCD-screen shows the vaginal resting pressure, which can be set to zero before measurements. Length of each contraction can be measured precisely with lines that can be moved across the screen to isolate the actual parameter being recorded. A silicone ring is located at the end of the probe to provide control for standardized depth of insertion. The readings are given in hectoPascals (hPa). The device was tested for reliability and found to have an intra-observer reliability measured by Intraclass Correlation Coefficient (ICC) of 0.97 [24].

Birth outcome

Data on length of the second stage of labor in minutes, birth weight in grams, infant's head circumference in cm, episiotomy (yes or no), degree of perineal tear (first to fourth degrees), perineal analgesia (yes or no) and epidural analgesia (yes or no) were obtained from birth records.

Procedure

After a thorough instruction of how to perform a correct contraction and assessment of ability to contract with visual observation and vaginal palpation, the women were tested in a supine position with knees bent and legs slightly apart. The researcher (TS) supported the end of the probe manually during the tests.

PFM function was tested in three ways

1) Maximal voluntary contraction (MVC). The women were asked to contract the PFM three times as hard as possible and try to hold for 5 s. A ten second interval was provided between contractions. The strongest contraction was used for statistical analysis.
2) Endurance of PFM contraction. The women were asked to hold a PFM contraction as long as they could and were not interrupted unless the pressure measurements reached zero or they reported they could no longer hold the contraction. The holding time of the contraction in seconds was used for analysis.
3) Repeated contractions. The women were asked to repeat contractions of the PFM continuously, at least 15 times. The number of contractions was used for analysis.

Adequate rest (approximately 3–5 min) was given between the tests.

Statistical analysis

Statistical analysis of the data was performed using SPSS, v. 16 software (SPSS inc. Chicago, Illinois, USA). Background variables are reported as numbers and frequencies, and mean with standard deviation (SD). The changes in PFM MVC and endurance are reported as mean values with 95% confidence interval (95% CI). Changes in PFM strength and endurance before and after childbirth were calculated with a paired *t*-test. One-way ANOVA was used to compare changes in PFM function between groups of different mode of delivery.

P values <0.05 were considered statistically significant.

Results

In all, 36 women completed both measurements, with 8 women withdrawing from the study (Fig. 1). Analysis of women who withdrew showed no significant differences from the study group regarding demographic data or pregnancy outcome. One woman withdrew because she was not able to contract her PFM, and she did not want to continue. All the other participants were able to contract their PFM. At the time of the postpartum measurement, 33 participants were breastfeeding. All instrumental deliveries were performed with vacuum extraction and all episiotomies were performed as a right mediolateral one. Three women who underwent vacuum extraction had episiotomy and two in the normal vaginal delivery group.

Table 1 shows background variables. Women who had acute cesarean delivery were significantly older and had higher body mass index (BMI) than the two other groups.

Table 2 shows development of PFM strength and endurance before and after childbirth for all participants as one group.

Table 3 shows PFM strength and endurance before and after childbirth for different types of delivery. Before birth there were no significant differences in PFM strength or endurance (ability to hold a contraction and repeat fast contractions) between the three groups of deliveries.

The three groups showed different reductions in PFM strength. The difference was significant between normal

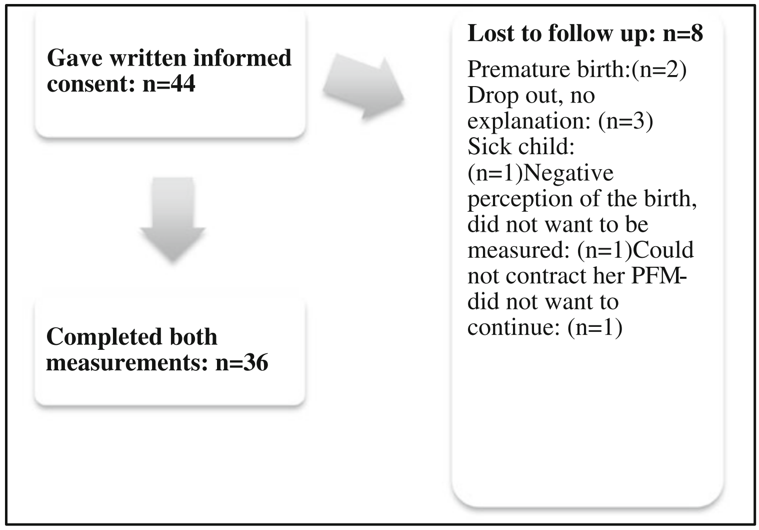

Fig. 1 Flow of participants and reasons for withdrawal

vaginal birth vs. acute cesarean birth (p=0.028) and between instrumental vaginal birth and acute cesarean birth (p=0.003), but not between normal vaginal and instrumental vaginal birth (p=0.173).

There was no significant difference between groups regarding endurance changes measured as holding time of a sustained PFM contraction (p=0.212). All women were also able to perform at least 15 repeated contractions both during pregnancy and after birth except one woman who was not able to contract her PFM 6 weeks postpartum (Table 3).

Discussion

The results showed that PFM strength and endurance were significantly decreased after first childbirth for the whole group of participants. PFM strength was significantly decreased after vaginal delivery, both normal and with instrumental assistance, 6 to 12 weeks postpartum, but endurance was not significantly influenced by mode of delivery.

Our results of higher maternal age and increased maternal BMI in the acute cesarean section group were similar to other studies. Both have been found to be associated with increased obstetric interventions [25–27].

Our results are in line with other studies, showing that PFM strength is reduced after first vaginal delivery [3, 7, 15]. However, methods of measurements and measurement procedures vary and the actual figures can therefore not be compared between studies [28]. In the present study, we did not find significant differences in strength reduction between normal (or spontaneous) and instrumental deliveries. Our group of instrumental deliveries consisted only of vacuum assisted deliveries and no forceps deliveries. Vacuum deliveries have been found to be less traumatic for the pelvic floor musculature than forceps [11] which could be one reason for these results. Our group of instrumental deliveries was also small, consisting of five participants only. This did not fulfill the power calculation criteria of eight participants in each group, increasing the risk of type II error. However, our result of differences between strength changes of both groups of vaginal deliveries and the cesarean section group were highly significant. Limitations in recruiting participants resulted in different sized groups. A period of 1 year was considered to be adequate time for data collection. Women were recruited during their pregnancy and at that time it was not possible to predict mode of delivery.

Allen et al. (1990) measured all participants, i.e. primiparas after cesarean section and vaginal delivery in one group. Their results were similar to our findings

Table 1 Maternal and infant variables by groups of normal vaginal, instrumental vaginal and acute cesarean birth. Values are presented as mean (SD)

	Normal vaginal birth (n=26)	Vaginal instrumental birth (n=5)	Acute cesarean section (n=5)	p value
Maternal age	25.5 (3.6)	26.2 (1.6)	32.6 (5.3)*	0.002
Pre-preg. BMI	23.7 (4.2)	22.2 (2.5)	28.3 (3.6)*	0.044
Birth weight (g)	3533 (434)	3384 (278)	3907 (331)	0.112
Infants head circumference (cm)	35.1 (1.5)	35.8 (1.5)	35.8 (1.0)	0.423

* $p<0.05$, significantly different compared with the two other groups

Table 2 Development of PFM function from mid-pregnancy (20–26 weeks of gestation) to after childbirth (6–12 weeks postpartum) for all participants (*n*=36). PFM strength presented as mean with 95% CI of MVC of vaginal squeeze pressure (hPa), PFM endurance, mean with 95% CI of holding time in seconds and repeated contractions (number of women doing at least 15 contractions)

	Mid-pregnancy	Postpartum	*P* value
MVC (hPa)	42.1 (36.3; 47.9)	21.9 (17.8; 26.1)	<0.0001
Endurance (s)	146.1 (104.8; 187.4)	71.9 (47.5; 96.4)	<0.0001
Endurance (at least 15 repeated contractions) (*n*)	36	35[a]	

[a] One woman was not able to contract her PFM 6 weeks postpartum

regarding significant reduction in PFM strength due to first childbirth. However, no details were given regarding methodology of evaluating and how vaginal squeeze pressure was measured [3].

The results on strength changes due to mode of delivery correspond with two studies using similar measurement techniques, group of participants and measurement time points [7, 15]. Peschers et al. [7] found a significant reduction in PFM strength in primiparas 6 to 10 weeks postpartum compared with values during the last month of gestation. No changes in PFM strength was found in women who had elective cesarean section and it was concluded that PFM strength was impaired shortly after vaginal delivery but returned to normal within 2 months for most women [7]. They did not specify different types of vaginal delivery. Peschers et al. also quantified PFM strength by vaginal palpation and found no significant change from antepartum to postpartum values [7]. There is, however, some concern related to the responsiveness, reliability and validity of quantifying strength with vaginal palpation [22], and this may explain that changes are difficult to detect using digital palpation.

Meyer et al. [15] studied the effects of birth on PFM strength. Their results showed that women who delivered by cesarean section had no significant reductions in PFM strength, while women who delivered vaginally showed significant reduction in PFM strength, thereof instrumentally (forceps) assisted deliveries had the most marked reduction in strength [15]. In their study, no detailed description was given on the methods of measuring vaginal squeeze pressure or how ability to contract the PFM correctly was evaluated. Although similar methods were used in these studies as in the present study, caution must be taken when comparing results as variations exist, both in the technical parameters of the apparatus as well as the size of the probe and instructions given to the participants [29]. The method used in our study has shown to be reproducible [24, 30] and validity was ensured by only registering contractions with simultaneous inward movements of the probe [21].

When measuring endurance (ability to hold a contraction for as long as possible) a huge variation in the duration of the contractions was observed between the women. Although we saw a significant reduction in this function for all women as one group, we did not find differences between the three groups of different modes of delivery. The large confidence intervals for this variable in each group overlapped, making interpretation difficult [31]. A type II error due to small sample size may be one explanation, i.e. the study lacks power to detect significant differences when it exists, but also a possible measurement error in muscle endurance, may have occurred. Dumoulin et al. found weak correlation when testing intra-rater reliability for endurance of the PFM with a dynamometer [32]. There is sparse data on PFM endurance changes due to childbirth, but Marshall et al. found significantly less endurance of the PFM, 9 to 10 months postpartum in women who had delivered once, compared with another group of women who had never given birth [6].

Table 3 Development of PFM function from mid-pregnancy (20–26 weeks of gestation) to after childbirth (6–12 weeks postpartum) for different modes of delivery. Mean with 95% CI of vaginal squeeze pressure (hPa) PFM endurance as mean with 95% CI of holding time in seconds and number of women (*n*) able to do at least 15 repeated contractions

	Normal vag. (*n*=26)	Instr. vag. (*n*=5)	Acute ces. sect. (*n*=5)	*p* value
MVC during mid-pregnancy (hPa)	41.6 (35.1; 48.2)	48.4 (18.8; 78.0)	38.2 (16.7; 59.7)	0.637
MVC after childbirth (hPa)	20.8 (16.2; 25.3)	17.0 (9.3; 24.6)	33.0 (10.8; 55.2)	0.069
Difference in MVC (hPa)	20.5 (16.5; 24.5)	31.4 (7.4; 55.4)	5.2 (−6.6; 17.0)*	0.003
Endurance during mid-pregnancy (s)	154.3 (103.4; 205.3)	150.2 (−48.1; 348.5)	99.2 (41.9; 156.5)	0.662
Endurance after childbirth (s)	71.4 (45.5; 97.3)	50.0 (−9.1; 109.1)	96.8 (−61.7; 255.3)	0.600
Difference in endurance (s)	83.0 (45.0; 120.9)	100.2 (−39.7; 240.1)	2.4 (−128.9; 133.7)	0.212
15 rep. contr. during mid-pregnancy (*n*)	26	5	5	
15 rep. contr. after childbirth (*n*)	25[a]	5	5	

* $p<0.05$, significantly different compared with the two other groups

[a] One woman was not able to contract her PFM postpartum

In our study, continuously repeated contraction seemed to be the easiest way to contract the muscles postpartum. All women except one were able to perform this task without difficulties postpartum. However, endurance, defined as the ability to perform repeated contractions have been found by other authors to be unreliable [33]. We have not been able to find other studies investigating the effects of modes of delivery on PFM endurance, and further investigations are warranted.

Considering the complicated event of childbirth, many extraneous variables such as selection biases and different obstetric practices can influence the results. In our study we tried to focus on good and standardized methodology regarding evaluation and measurement of PFM contraction. In the present study, blinding was not possible because this study was a one student's research and circumstances for blinding were not available. The assessor was not blinded against the mode of delivery when the women came to second measurement. However, it was kept as a rule, not to talk about the delivery during the measurements and to try to avoid as much as possible, observational bias. Difference in measurement time periods during pregnancy as well as postpartum can also influence actual results [34, 35]. We did not measure possible changes in PFM strength during the course of pregnancy, which has not been widely studied by others either. Dietz et al. stated that "the effect of pregnancy on the pelvic floor muscle is unknown and may well be significant, given the fact that progesterone is a muscle relaxant" [36]. Our main limitation is the small sample size and that no measurements were done in the immediate period after delivery. However, ability to contract PFM soon after delivery can be influenced by pain and may not correctly classify muscle strength [7]. Larger studies are warranted including measurements during the course of pregnancy and immediately before and after the start of labor.

Conclusion

This study showed that pelvic floor muscle strength and endurance was significantly decreased in general after first childbirth. Pelvic floor muscle strength was significantly affected by vaginal delivery, both after normal birth and with instrumental assistance, 6 to 12 weeks postpartum. Significant changes in endurance measured as the ability to hold a contraction and to repeat fast contractions were not detected. These results may have been influenced by a relatively small sample size and large confidence intervals, and further larger studies are warranted.

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Conflicts of interest None.

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