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Longitudinal changes in pelvic floor muscle strength among parous women

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Abstract

BACKGROUND: There is limited knowledge of the effects of time on change in pelvic floor muscle strength after childbirth.

OBJECTIVE: The objectives of this study were to estimate the change in pelvic floor muscle strength in parous women over time and to identify maternal and obstetric characteristics associated with the rate of change.

STUDY DESIGN: This is an institutional review board-approved prospective cohort study of parous women. Participants were recruited 5–10 years after first delivery and followed annually. Pelvic floor muscle strength (peak pressure with voluntary contraction) was measured at 2 annual visits approximately 4 years apart with the use of a perineometer. We calculated the change in peak pressures, which were standardized per 5-year interval. Linear regression was used to identify maternal and obstetric characteristics that are associated with the rate of change in peak

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pressure. The obstetric variable of greatest interest was delivery group. Participants were classified into 3 delivery groups (considering all deliveries for each multiparous woman). Delivery categories included cesarean only, at least 1 vaginal birth but no forceps-assisted deliveries, and at least 1 forceps-assisted vaginal birth. Statistical analysis was completed with statistical software.

RESULTS: Five hundred forty-three participants completed 2 perineometer measurements with a median 4 years between measures (interquartile range, 3.1—4.8). At initial measurement, women were, on average, 40 years old and 8 years from first delivery. Initial strength was higher in participants who delivered all their children by cesarean (38.5 cm H₂O) as compared with women with any vaginal non-forceps delivery (26.0 cm H₂O) or vaginal forceps delivery (13.5 cm H₂O; $P<.001$). There was a strong correlation between the first and second perineometry measurement ($r=0.84$). Median change in pelvic floor muscle strength was small at 1.2 cm H₂O per 5 years (interquartile range, -5.6, 9.9 cm H₂O). In multivariable analysis, women who delivered by cesarean only demonstrated almost no change in strength over 5 years (0.2 increase cm H₂O per 5 years); those who experienced at least 1 vaginal or vacuum delivery increased strength (4.8 cm H₂O per 5 years) as did women with at least 1 forceps delivery (5.0 cm H₂O per 5 years). Additionally, obese women had a significant reduction in strength (-3.1 cm H₂O per 5 years) compared with normal weight participants (0.2 cm H₂O per 5 years).

CONCLUSION: Among parous women, pelvic muscle strength increased minimally over time with an average change of 1.2 cm H₂O per 5 years; change in strength was associated with mode of delivery and obesity.

Keywords

cesarean; pelvic floor muscle strength; perineometry

The pelvic floor muscles, the levator ani, are a group of striated muscles that provide constant tone and structural support for pelvic organs. Weak pelvic floor muscles are associated with pelvic floor disorders that include stress urinary incontinence,^{1–3} anal incontinence,⁴ and pelvic organ prolapse.^{2,4,5} The levator ani muscles are prone to injury during a vaginal delivery by the fetal head forcibly lengthening the muscle.⁶ Additionally, the impact of the fetal head on the muscle can lead to an ischemia and reperfusion injury that results in persistent myopathic changes that include the loss of hypertrophy and less resistance to stretch.⁷ There is functional evidence of such muscle injury after childbirth, as demonstrated by a decrease in pelvic floor muscle strength that is associated with a women's obstetric history,² both in the immediate postpartum period³ and almost a decade after childbirth.⁴

We know from rheumatologic and geriatric literature that skeletal muscle strength decreases with age. Very little is known, however, about the effect of time on pelvic floor muscle strength. The objective of the present research is to describe the change on pelvic floor muscle strength over time and to investigate what demographic or obstetric factors influence the rate of change in pelvic floor muscle strength.

Materials and Methods

Subjects

This is a supplementary study to the Mothers' Outcomes after Delivery (MOAD) study, a prospective cohort study of pelvic floor outcomes in parous women who were recruited 5–10 years after first delivery. Recruitment methods for the MOAD study have been described previously.⁸ Briefly, women were recruited based on the mode of delivery and matched for age and time since first delivery. For the MOAD study, all participants provided written informed consent. Additional consent was obtained for this supplemental study, which required the measurement of pelvic muscle strength at 2 points in time. For both studies, institutional review board approval was obtained.

Obstetric information was obtained from a review of hospital records. If the obstetric record was not available (<5% of deliveries), the woman's description of her birth was used to classify her obstetric exposures. The obstetric information that was abstracted included the mode of delivery, years since first delivery, and number of deliveries. For women with any vaginal delivery, we also collected information on a history of any macrosomia (infant weight >4000 g), prolonged labor (>120 minutes), episiotomy, or anal sphincter laceration. Women were also asked to report any interval delivery between the 2 perineometry measurements.

Participants were classified into three obstetric groups according to a modification of a classification system that had been used in our previous research.⁴ The first group was comprised of women who delivered all their children by cesarean, regardless of whether labor occurred before the cesarean birth. The second group was comprised of women who had experienced at least 1 vaginal or vacuum-assisted vaginal birth but no forceps-assisted deliveries. The third group was comprised of women who had experienced at least 1 forceps delivery. The rationale for this classification system was that previous research in this cohort suggested that pelvic muscle strength 6–11 years from delivery was reduced significantly after vaginal birth compared with cesarean birth and was further reduced after forceps delivery.⁴

Peritron perineometer measurements

Pelvic floor muscle strength was measured with the Peritron perineometer (CardioDesign, Oakleigh, Australia). The Peritron perineometer is a vaginal probe that measures pelvic floor muscle strength in centimeters of water. The Peritron perineometer has been shown to be valid, with accuracy of readings to ± 0.7 cm H₂O, and to have strong interrater reliability.^{9–11}

All MOAD participants were approached to participate in an initial perineometry assessment at their second annual MOAD study visit.⁴ Those who did not attend the second visit were invited subsequently to participate. Women with a latex allergy were excluded due to the presence of latex in the Peritron perineometer. From November 2013 through May 2015, women who had participated in the first strength measurement were recruited for a second assessment of muscle strength, with a goal to include each woman 4 years from the initial

measure. To recruit adequate numbers of women in the vaginal birth and forceps birth groups, recruitment was extended for women in these birth categories through March 2017.

Before insertion of the probe, participants were placed in lithotomy position and instructed to squeeze the pelvic floor muscles as if trying to hold in flatus; an investigator confirmed correct technique via palpation. The probe was then inserted into the vagina by a trained investigator, and the participant was instructed to squeeze the pelvic floor muscles as forcefully as possible and to relax the muscles when the contraction could no longer be maintained. This was repeated a second time after a 10-second rest interval. The mean of the maximum pressure recorded on 2 contractions was considered the peak pressure. Participants who were unable to perform a pelvic floor muscle contraction were assigned a value of zero.

Additional data for this study, including age, race, parity, and years since first delivery, were extracted from the MOAD study database. These data were collected for the MOAD study by a self-administered questionnaire that was completed at study enrollment and updated at annual visits. Additionally, body mass index (BMI), as measured by a study team member, was measured at each annual study visit. For time-varying characteristics, such as BMI, the measurement at the first assessment of pelvic floor muscle strength was used in our analysis.

Statistical analysis

Pearson's chi-squared (for categorical variables) and Kruskal-Wallis (for continuous variables) procedures were used to test the strength of the association between delivery group and maternal characteristics. Using changes in peak muscle strength as the outcome of interest, we used linear regression models to quantify and test associations with maternal characteristics and obstetric exposures that included the primary exposure of interest of each delivery group in all models. Among participants who had a history of vaginal delivery, Kruskal-Wallis tests were used to test for differences in 5-year changes in pelvic floor muscle strength. All statistical analysis was completed with the use of STATA software (version 14 SE; StataCorp 2015, College Station, TX). Statistical significance was defined at the 5% significance level.

Results

Of the 1529 participants in the MOAD study, 1143 completed an initial pelvic floor muscle strength measurement at 6–11 years after the first delivery (November 2009 to October 2014). Reasons MOAD participants did not have an initial perineometry measurement include no follow-up visit after initial recruitment (n=297), latex allergy (n=42), declined (n=25), equipment failure (n=5), and other reasons (n=17). The second perineometry measurement was obtained approximately 4 years later (between November 2013 and March 2017). A second perineometry measure was not obtained for 519 participants because they either did not attend a visit during the period of data collection or had not been in the longitudinal study for a sufficient duration at the time of the collection of the second measure. In addition, some participants did not complete a second perineometry measurement because of a new latex allergy (n=7), equipment failure (n=4), or declined to participate (n=5). Thus, 608 participants completed 2 perineometry measurements. For this

analysis, we excluded data from 63 of 608 participants who had a second measurement <2 years from the first measurement and from 2 women whose perineometry measurements were significant outliers and therefore assumed to be erroneous. Therefore, 543 participants contributed data to this analysis. There were no significant differences in initial peak pressure between participants who had only 1 perineometry measurement and those who completed a second measurement (29.0 vs 27.5 cm H₂O; $P=.089$).

Participant demographics for the 543 women who were included in this analysis are summarized in Table 1. At the time of the initial perineometry assessment, participants were, on average, 8 years after the first delivery (interquartile range [IQR], 7.0–10.0) and 40 years old (IQR, 36.6–44.1). Mean parity for all delivery groups was 2. Compared with women with any vaginal delivery, participants with only cesarean delivery were more likely to be obese ($P<.001$) and farther from first delivery ($P<.001$; Table 1). Twenty-eight women (5%) reported participation in a formal program of pelvic floor muscle exercises at any time between the first and second measurement; participation was distributed evenly across delivery groups. Twenty-five participants had an interval delivery between measurements: 2 women from the cesarean-only group, 22 women from the non-forceps vaginal delivery group, and 1 woman from the forceps group.

At the initial perineometry measurement, women who delivered all their children by cesarean delivery had stronger pelvic floor muscles (median, 38.5 cm H₂O) than those with at least 1 vaginal non-forceps birth (median, 26.0 cm H₂O) or women with at least 1 vaginal forceps delivery (median, 13.5 cm H₂O; $P<.001$). There were no differences in initial pelvic floor muscle strength based on race ($P=.940$), age at measurement ($P=.982$), years from first delivery ($P=.062$), BMI ($P=.068$), or parity ($P=.071$).

The median interval between measurements was 4 years (IQR, 3.1–4.8). There was a strong correlation between first and second perineometry measurements ($r=0.84$; Figure 1). Over the 4 years between measurements, the actual change in pelvic floor muscle strength for all participants was 1.0 cm H₂O (IQR, –4.5 to 7.5 cm H₂O). From this observation, we calculated a 5-year standardized rate of change of 1.2 cm H₂O per 5 years (IQR, –5.6 to 9.9 cm H₂O; Figure 2).

The change in pelvic floor muscle strength was considered to be a function of obstetric and maternal characteristics (Table 2). There were significant differences in the change in pelvic floor muscle strength based on delivery group (Figure 3). Specifically, participants with a history of only cesarean delivery had an overall decrease in pelvic floor muscle strength of –1.4 cm H₂O per 5 years. Compared with participants with only cesarean deliveries, those with at least 1 vaginal non-forceps delivery had a significant increase in pelvic floor muscle strength of 3.7 cm H₂O ($P<.001$), as did participants with a history of a vaginal forceps delivery who had an increase of 4.2 cm H₂O ($P=.017$). Although the number of women with an interval delivery was only 25, we assessed whether change in strength was different in this subset. No difference was identified; the median change in strength per 5 years for participants with an interval delivery was 0.5 cm H₂O (IQR, –4.0 to 7.5) compared with 1.0 cm H₂O (IQR, –4.5 to 7.5) for participants without an interval delivery.

Because of the significant effect of delivery method on pelvic floor muscle strength, we treated delivery group as our primary exposure and adjusted for this variable in all models. There were no differences in change in pelvic floor muscle strength based on maternal age, race, parity, or years since first delivery (Table 2). BMI was associated with change in pelvic floor muscle strength in that obese individuals had a significant decrease in pelvic floor muscle strength over 5 years compared with normal weight participants (-3.1 vs 0.2 cm H₂O; $P=.047$) when adjusted for delivery group. In the model that controlled for BMI, delivery group remained significantly associated with a change in pelvic floor muscle strength. Specifically, women who delivered by cesarean-only demonstrated almost no change in strength over 5 years (0.2 increase cm H₂O per 5 years); those who experienced at least 1 vaginal non-forceps delivery increased strength (4.8 cm H₂O per 5 years) as did women with at least 1 vaginal forceps delivery (5.0 cm H₂O per 5 years).

Analysis of exposures unique to women with any vaginal delivery found that there were no differences in change in pelvic floor muscle strength, which included a history of a macrosomic infant ($P=.863$), prolonged labor ($P=.661$), or episiotomy ($P=.789$). There was, however, a significant difference based on the presence of any previous anal sphincter laceration where women without a sphincter laceration had a significantly greater improvement in muscle strength (3.2 vs 0.0 cm H₂O per 5 years; $P=.008$).

Comment

The results of this research indicate a minimal change in pelvic floor muscle strength in parous women over 3—5 years. Based on physiologic and geriatric literature that reported an age-related decline in skeletal muscle strength at rates of 0.37 — 3% per year,^{12–14} we suspected that pelvic floor muscle strength similarly would decline over time. Our findings are surprising, in that we observed a very small increase in strength among the cohort. As a reference, 16 weeks of physical therapy is expected to increase pelvic floor muscle strength by 3 — 13 cm H₂O.^{3,15,16} Given that the estimated range of change for all participants was very close to zero, our findings could be interpreted as evidence of no meaningful change in pelvic floor muscle strength over time.

We observed significantly different changes in strength by delivery group. An increase in strength was greatest among women who had any forceps delivery and was not observed among women who delivered exclusively by cesarean delivery. However, initial strength was greatest among women who had delivered all their children by cesarean delivery (median, 38.5 cm H₂O). Comparatively, initial strength was approximately one-third lower among those women with at least 1 vaginal non-forceps birth (median, 26.0 cm H₂O) and almost two-thirds lower among women with at least 1 forceps delivery (median, 13.5 cm H₂O). Thus, initial strength is lowest in the forceps group, but this is also the group with the greatest improvement in strength over time. We speculate that the primary insult of the vaginal delivery to the pelvic floor has an impact on pelvic floor muscle strength, which may slowly recover over time. Given the small change that was observed, it is unlikely that women with a vaginal delivery can “catch up” to the strength of women with a cesarean delivery over time. Furthermore, our results suggest that the ability of the muscles to recover function after delivery is blunted by being obese, irrespective of the mode of delivery.

Although many studies have shown a decline in pelvic floor muscle strength in the same woman, comparing antepartum measures with immediate postpartum assessment,^{3,17,18} we are unaware of any previous study that has evaluated the change in pelvic floor muscle strength longitudinally outside of the peripartum period. Two small cross-sectional studies evaluated the effect of age on pelvic floor muscles. Quarterly et al¹⁹ evaluated muscle strength in a small group of community-dwelling women of variable parity, one-half of whom were 40 years old, and found no significant difference in strength based on age. Trowbridge et al²⁰ evaluated pelvic floor muscle strength in approximately 15 nulliparous women per decade of life who were 20–70 years old and found no difference in strength based on age.

Limitations of our research include the lack of a nulligravid control group or prepregnancy measurement to assess baseline function. Although we had 4 years between measurements, this may be too short a period for optimal assessment of change in muscle strength. Given the nature of an observational study, we are unable to determine whether the small change in pelvic floor muscle strength that was seen is due to aging or other reasons. Additionally, participants in the MOAD study are not seeking treatment for pelvic floor disorders, but they may have a greater awareness of pelvic floor disorders because of participation in the study and thus seek treatment for pelvic floor disorders and practice pelvic floor muscles exercises more than the general population.

Strengths of our study include prospective collection of data from a large sample size with representation of all delivery methods. Additionally, we used a validated measurement tool, the Peritron perineometer, and a standardized script to improve reproducibility of measures between observers. The examiners were blinded to method of delivery to reduce bias. Record review was used to verify accuracy of obstetrics data to limit report bias.

Although pelvic muscle strength is associated strongly with obstetrics history, further changes over time appear to be relatively minimal. Furthermore, our results suggest being obese leads to worsening strength over time. This finding supports the need to counsel patients about the importance of maintaining a normal BMI to prevent weakening of pelvic floor muscles, regardless of the method of delivery, because weak pelvic floor muscles are associated with pelvic floor disorders of prolapse and incontinence.

Additional studies are needed to increase understanding of the effect of age and time on pelvic muscle strength after delivery and to clarify the role that pelvic muscle strength plays in the genesis of pelvic floor disorders.

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AJOG at a Glance**Why was this study conducted?**

Our objective was to understand the change in pelvic floor muscle strength over time and to identify factors that may influence the rate of change.

Key Findings

In this cohort of parous women, pelvic floor muscle strength changed minimally over 5 years. The change in strength was associated with mode of delivery and obesity.

What does this add to what is known?

This study adds new data on factors that influence the change in pelvic floor muscle strength over time.

FIGURE 1. Correlation of initial (x-axis) and follow-up (y-axis) mean peak pelvic floor muscle strength for all participants

Scatterplot of mean peak pelvic floor muscle strength among 543 participants at first measure (x-axis) and follow-up measure (y-axis). Each dot represents one participant. The correlation coefficient was 0.84.

Myer et al. Changes in pelvic floor muscle strength. Am J Obstet Gynecol 2018.

FIGURE 2. Five-year change in peak pelvic floor muscle strength for all participants
Distribution of the change in pelvic floor muscle strength (mean peak pressure in centimeters of water) per five-years as measured with perineometry among 543 participants. Myer et al. Changes in pelvic floor muscle strength. Am J Obstet Gynecol 2018.

FIGURE 3. Box-percentile plot

Box percentile plot depicts the 5-year change in peak pelvic floor muscle strength, stratified by delivery grouping. The width of each plot is proportional to the number of women in the delivery group; each line in the plot corresponds to each percentile of the group.

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TABLE 1

Participant characteristics at first visit at which strength was measured

Characteristics	Cesarean only (n=185)	Vaginal, no forceps (n=305)	Vaginal forceps (n=53)	P value
Black race, % (n)	13 (24)	10 (30)	4 (2)	.139
Years since first delivery, % (n) ^a				<.001
<8	29 (53)	60 (184)	43 (23)	
8	71 (132)	40 (121)	57 (30)	
Maternal age, % (n) ^b				<.001
<40 y	41 (75)	55 (168)	32 (17)	
40 to <45 y	33 (62)	33 (100)	43 (23)	
45 y	26 (48)	12 (37)	25 (13)	
Body mass index, % (n)				<.001
<25 kg/m ²	40 (74)	55 (166)	68 (36)	
25 to <30 kg/m ²	30 (56)	27 (83)	19 (10)	
30 kg/m ²	30 (55)	18 (56)	13 (7)	
Parity, % (n)				.045
1	27 (49)	21 (65)	34 (18)	
2	62 (115)	60 (181)	47 (25)	
3	11 (21)	19 (59)	19 (10)	
Median peak pressure, cm H ₂ O (interquartile range)	38.5 (22.5—50.5)	26.0 (16.0—35.0)	13.5 (9.0—24.0)	<.001

^aYears since first delivery was dichotomized at the median of 8 years;^bMaternal age was classified into tertiles based on the ages of the entire cohort.

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TABLE 2

Change in pelvic muscle strength per 5 years according to the participant characteristics, adjusted for delivery group

Primary exposure	Change in mean peak pressure per 5 years, mean (standard error)	P value ^a
Delivery group		
Cesarean only (n=185)	-1.4 (1.19)	Reference
Vaginal, no forceps (n=305)	3.7 (0.84)	<.001
Vaginal, forceps (n=53)	4.2 (1.31)	.017
Covariates		
Race		
Non-black (n=487)	-1.6 (1.12)	Reference
Black (n=56)	0.7 (2.13)	.269
Years since first delivery ^b		
<8 (n=260)	0.01 (1.44)	Reference
8 (n=283)	-1.9 (1.15)	.153
Maternal age, y ^c		
<40 (n=260)	-1.0 (1.34)	Reference
40 to <45 (n=185)	-0.8 (1.42)	.887
45 (n=98)	-2.5 (1.66)	.416
Body mass index, kg/m ²		
<25 (n=276)	0.2 (1.34)	Reference
25 to <30 (n=149)	-1.7 (1.48)	.220
30 (n=118)	-3.1 (1.54)	.047
Parity		
1 (n=132)	-1.8 (1.55)	Reference
2 (n=321)	-1.1 (1.20)	.642
3 (n=90)	-2.0 (1.88)	.922

^aProduced by linear regression testing of the null hypothesis that the specified coefficient is different from zero (controlling for delivery group in all models);

^bYears since first delivery were dichotomized at the median of 8 years;

Maternal age was classified into tertiles based on the ages of the entire cohort.
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