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ORIGINAL RESEARCH

Influence of Different Obstetric Factors on Early Postpartum Pelvic Floor Function in Primiparas After Vaginal Delivery

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Purpose: This study sought to explore the obstetric factors affecting early postpartum pelvic floor function of primiparas after vaginal delivery.

Patients and Methods: We included 3362 primiparas who underwent postpartum re-examination in International Peace Maternity and Child Health Hospital at 42–60 days after delivery. The Glazer Protocol was used to evaluate their pelvic floor function, and univariate and multivariate logistic regression analyses were performed to identify obstetric factors that might affect it.

Results: Forceps-assisted delivery significantly increased the risk of the decline in fast- and slow-twitch muscle strength in the early postpartum period when compared with natural vaginal delivery ($P < 0.05$). Women with a pre-pregnancy body mass index (BMI) of ≥18.5 kg/m^2 had a decreased risk of decline in fast-twitch muscle strength than those with a pre-pregnancy BMI of <18.5 kg/m^2 ($P < 0.05$). Women who had a pre-pregnancy BMI of 24.0 to <28.0 kg/m^2 bore a decreased risk of decline in slow-twitch muscle strength than those with a pre-pregnancy BMI of <18.5 kg/m^2 ($P < 0.05$). The risk of decline in fast-twitch muscle strength and slow-twitch muscle in women with anemia during pregnancy was significantly increased ($P < 0.05$); women with second-stage labors of >2 h had an increased risk of fast-twitch and slow-twitch muscle strength decline than those with <2 h ($P < 0.05$).

Conclusion: Both pre-pregnancy underweight and obesity may cause impairment of early postpartum pelvic floor function. Forceps delivery, anemia during pregnancy, and the length of second stage of labor are independent factors leading to pelvic floor function impairment.

Keywords: surface electromyography, Glazer Protocol, anemia during pregnancy, forceps delivery, the second stage of labor, body mass index

Introduction

Pelvic floor dysfunction (PFD) is a group of functional organ abnormalities caused by weak pelvic floor support and pelvic organ displacement caused by various reasons, often manifested as pelvic organ prolapse (POP), urinary incontinence (UI), fecal incontinence and postpartum sexual dysfunction.[1] PFD is now considered a hidden epidemic. About 40% of women are affected by POP, whereas 1 in 3 to 4 women will experience UI and 1 in 10 will experience fecal incontinence.[2] Although PFD is a non-fatal disease, it not only affects the quality of life of women but also endangers their mental health, and it has attracted the scholars' attention globally. Pregnancy and childbirth are the most common independent risk factors among the many risk factors of PFD.[3] Some studies have shown that 75% of POP is caused by pregnancy and childbirth.[4] Between 25% and 50% of the women who deliver vaginally experience varying degrees of UI, FI, and POP within one year after delivery.[5]

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Pelvic floor muscle (PFM) is involved in the formation of the elastic female pelvic floor support system, and the impairment of its innervation is one of the causes of PFD.[6] There are mainly two types of muscle fibers in PFM, the Type I or slow-twitch fibers and the Type II or fast-twitch fibers. The former is responsible for the static support function of the pelvic floor and the latter for its dynamic function. Morphometric analysis of external anal sphincter (EAS), levator ani muscle (LAM) and puborectalis muscle has demonstrated that pelvic floor musculature is composed of slow twitch fibers (70%) and fast twitch fibers (30%).[7] The main pathophysiological mechanism of PFD is that muscle fiber injury leads to abnormal muscle tone or poor coordination of muscle contraction, causing further displacement or dysfunction of surrounding organs such as the uterus, bladder and rectum.[8] There are various methods for assessing PFD, including visual inspection, vaginal palpation, ultrasonography, magnetic resonance imaging, manometry, infrared thermal imaging, and surface electromyography (sEMG).[9,10] There is currently no gold standard for scientific research or clinical use, and each approach has its own specific advantages and disadvantages.

The sEMG signal is a one-dimensional time-series voltage signal obtained by surface electrode guidance, amplification and display during involuntary and voluntary activities of the neuromuscular system. Myoelectricity refers to weak neuromuscular electrical signals, and early neuromuscular dysfunction is manifested as abnormal myoelectric signals. Therefore, PFM dysfunction can be reflected in myoelectric recordings.[11] The application of sEMG signal in assessing neuromuscular function of the pelvic floor muscle has been frequently reported because of its reliability and non-invasiveness.[12] The Glazer pelvic floor sEMG assessment protocol (Glazer Protocol for short) was proposed by Glazer and Marinoff in 1997 and is a PFM electromyography assessment method that has been proven to be reliable and effective.[13] Nevertheless, the influence of various obstetric factors on early pelvic floor function has remained controversial. This study aimed to identify the possible obstetric causes of pelvic floor functional impairment. To do this, we studied the results of early postpartum sEMG examination of pelvic floor muscles and obstetric factors that may lead to impaired pelvic floor function in primiparous women after vaginal delivery. There are many ways to treat pelvic dysfunction, especially from 42 days postpartum to 60 days postpartum, which is the golden period of recovery.[14] Therefore, timely screening and intervention of high-risk groups can be conducted to prevent and reduce the occurrence of postpartum and long-term PFD.

Materials and Methods

Study Participants

A total of 3362 primiparous women with singleton pregnancy that underwent vaginal delivery and voluntary postpartum pelvic floor function screening at the International Peace Maternity and Child Health Hospital affiliated to Shanghai Jiao Tong University from September 2019 to December 2021 were included as the research subjects. Participants all officially consented both verbally and in writing to participate in the study, and the study was approved by the Ethics Committee of the International Peace Maternity and Child Health Institute of Shanghai Jiao Tong University School of Medicine. The study conforms to the Declaration of Helsinki.

Inclusion and Exclusion Criteria

The inclusion criteria were 1) primiparas after vaginal delivery; 2) singleton pregnancy with fetal head display; 3) normal mental state with good cooperation during inspection.

The exclusion criteria were 1) history of chronic constipation, urinary leakage, pelvic floor disorders, and pelvic surgery; 2) severe hearing impairment, intellectual disability, severe cardiorespiratory insufficiency; 3) failure to properly contract the PFM under physician guidance; 4) presence of abdominal or internal hip muscle hypercontraction during evaluation; 5) presence of abdominal muscle sEMG of >10 μV during PFM contraction.

Research Methods

All subjects were assessed for pelvic floor function at 42–60 days postpartum by measuring pelvic floor muscle sEMG signals using vaginal surface electrodes (Glazer Protocol). The obstetric-related data were retrieved from the electronic medical record of the hospital, including maternal age, gestation, parity, level of education, pre-pregnancy body mass

index (BMI), gestational age at delivery, neonatal birth weight, labor analgesia administration, weight gain during pregnancy, and pregnancy complications.

Evaluation Methods and Diagnostic Indicators

In this study, a neuromuscular stimulation instrument (SA9800, MLD B4, Medlander Medical Technology Inc., Nanjing, China) was used for sEMG testing, and the sEMG signal acquisition device was a custom-made vaginal metal probe (CACB04, MLD V1, Medlander Medical Technology Inc., Nanjing, China). Software analysis was performed on a MYOTRAC Infiniti system (Montreal, Canada), and the final results were expressed in μV. Participants were placed in a supine position with a pear-shaped vaginal metal probe placed inside the vagina and the electrode devices placed on the hip adductor, gluteus and abdominal muscles to monitor unwanted muscle activation. All operations were handled by professionally trained medical staff in the Pelvic Floor Screening and Rehabilitation Center of International Peace Maternity and Child Health Hospital. Prior to the test, all subjects were informed of the complete test procedure and instructed how to properly contract the PFM to avoid abdominal and internal hip muscle crosstalk. During the assessment, a visual screen with voice prompts instructed subjects when to contract and when to relax. Professional medical staff provided personalized guidance and practice opportunities for the participants, and all participants completed the test successfully.

As per the Glazer Protocol, we divided the test into two phases: a fast-twitch muscle (Type II fiber) phase and a slow-twitch muscle (Type I fiber) phase. During the fast-twitch muscle evaluation phase, after short-term pelvic floor muscle contractions, the maximum (peak) values were recorded, and the fast-twitch muscle function was evaluated. During the slow-twitch muscle evaluation phase, five slow and gentle PFM contractions and a sustained maximum contraction for 10 seconds were performed with the reported values being the average of five measurements. This stage can evaluate slow-twitch muscle strength and fast-slow muscle coordination. A maximum value of >40 μV was considered normal, while a maximum value of less than 40 μV indicated the decline of fast muscle strength during the fast-twitch muscle (Type II fiber) phase. A maximum value of >35 μV was considered normal, while a maximum value of <35 μV indicated decreased slow muscle strength in the slow-twitch muscle phase (Type I fiber).[15,16]

Statistical Methods

R36.0 (IBM Corp., Armonk, NY) statistics software was applicated, and the chi-squared test was used for each factor to carry out univariate analysis. An α=0.05 (two-sided) was used for inspection level. Multivariate logistic regression analysis was performed on the factors with significant differences.

Results

Basic Information

We enrolled 3362 eligible participants (Figure 1), among whom 2936 (87.33%) gave birth by natural vaginal delivery and 397 (11.81%) using forceps-assisted delivery as shown in Table 1.

Analysis of Factors Influencing Pelvic Floor Function of Primiparas After Vaginal Delivery in the Early Postpartum Period

Maternal age, pre-pregnancy BMI, weight gain during pregnancy, level of education, pregnancy anemia, natural conception, gestational age at delivery, mode of delivery, use of analgesics or perineal tear during delivery, duration of the second stage of labor, placenta delivery situation, intrapartum and postpartum hemorrhage, whether neonates performed early contact and sucking, and neonatal birth weight were assigned to 15 categories of variables (Table 2).

Maximum sEMG Value in Fast-Twitch Muscle (Type II Muscle Fiber) Phase

Univariate analysis showed that pre-pregnancy BMI, anemia during pregnancy, the presence or absence of forceps, perineal tears and lateral episiotomy, duration of the second stage of labor, and postpartum hemorrhage were likely to cause a decrease in the maximum sEMG during the fast-twitch muscle (Type II muscle fiber) phase. The former was

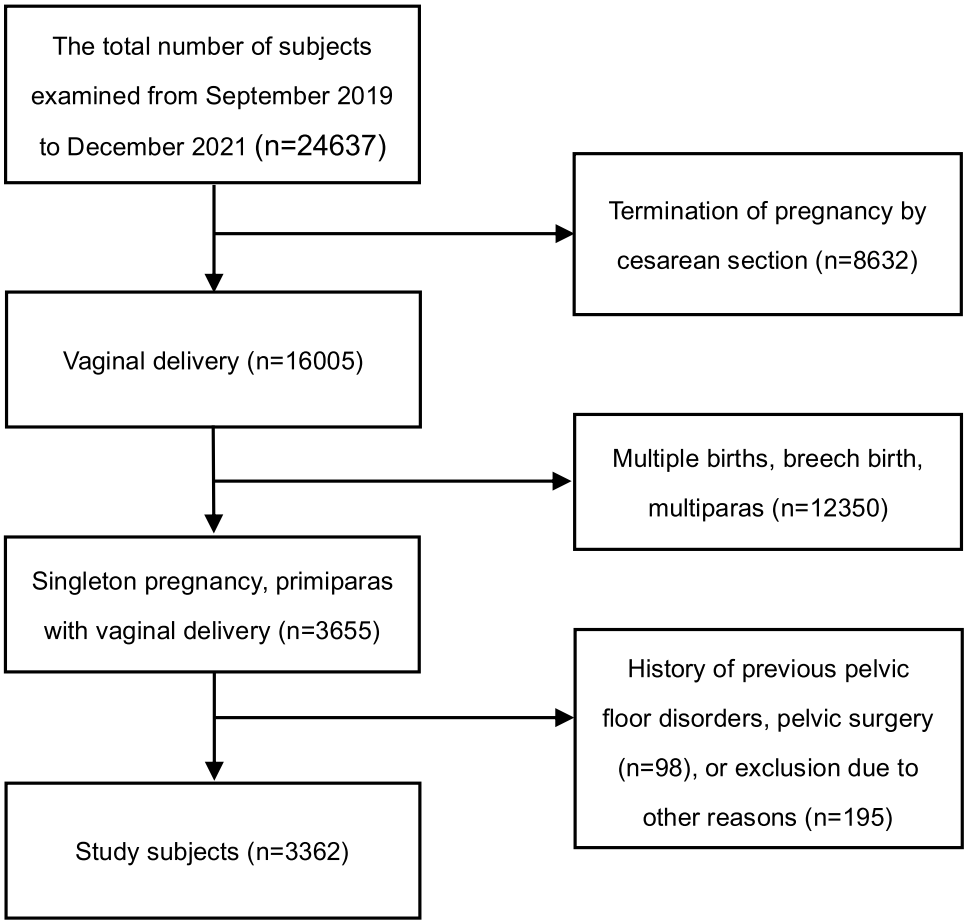

Figure 1 Flowchart of the protocol used to select the study population.
Abbreviations: OR, odds ratio; CI, confidence interval.

selected as the dependent variable, and the variables with statistical difference in univariate analysis were taken as independent variables for multivariate logistic regression analysis ($P < 0.05$). The results showed that women with a pre-pregnancy BMI of 18.5–24.0 kg/m^2, 24.0–28.0 kg/m^2 and ≥28.0 kg/m^2 had a decreased risk of fast-twitch muscle

Table 1 Basic Information of Study Participants

Possible Influencing Factors	Cases (N)	Percent (%)
Age (Years)		
<25	129	3.84
25–34	3011	89.56
≥35	222	6.60
Pre-pregnancy BMI (kg/m^2)		
<18.5	552	16.42
18.5 to <24.0	2470	73.47
24.0 to <28.0	284	8.45
≥28.0	56	1.67
Gestational weight gain (kg)		
<12	1068	31.77
12 to <20	1990	59.19
≥20	304	9.04

(*Continued*)

Table 1 (Continued).

Possible Influencing Factors	Cases (N)	Percent (%)
Level of education		
Lower than junior college	108	3.21
Junior college	520	15.47
Undergraduate	1795	53.39
Graduate and above	939	27.93
Gestational anemia		
Positive	717	21.33
Negative	2645	78.67
IVF		
Yes	164	4.88
No	3198	95.12
Gestational age (weeks)		
34 to <37	120	3.57
37 to <40	2249	66.89
≥40	993	29.54
Mode of delivery		
Vaginal delivery/natural childbirth	2936	87.33
Forceps-assisted delivery	397	11.81
Vacuum-assisted delivery	29	0.86
Labor analgesia		
Yes	2398	71.33
No	964	28.67
Perineal laceration/lateral episiotomy		
Integral perineum	44	1.31
First-degree tear	1082	32.18
Second-degree tear	1284	38.19
Lateral episiotomy	952	28.32
<2	3131	93.13
≥2	231	6.87
Delivery of placenta		
Manual	142	4.22
Spontaneous	3220	95.78
Intrapartum/postpartum hemorrhage (mL)		
<500	3268	97.20
500 to <1000	70	2.08
≥1000	24	0.71
Early contact and sucking		
Yes	2824	84.00
No	538	16.00
Birth weight of newborn (g)		
<2500	53	1.58
2500 to <3500	2436	72.46
3500 to <4000	788	23.44
≥4000	85	2.53

Abbreviations: BMI, body mass index; IVF, in vitro fertilization.

strength decline than those with a pre-pregnancy BMI of <18.5 kg/m^2 at 6–8 weeks after delivery (odds ratio [OR] 0.752, 95% confidence interval [CI] 0.614–0.921; OR 0.626, 95% CI 0.462–0.849; OR 0.551, 95% CI 0.313–0.970, respectively). Anemia during pregnancy was associated with increased risk of fast-twitch muscle strength decline (OR 1.243, 95% CI 1.038–1.489). Forceps-assisted delivery was associated with an increased risk of fast-twitch muscle

Table 2 Assignment of Factors Influencing Pelvic Muscle Function in Primipara

Variable	Factor	Assignment Criteria
X1	Age (years)	<25=1; 25–34=2; ≥35=3
X2	Pre-pregnancy BMI (kg/m^2)	<18.5=1; 18.5 to <24.0=2; 24.0 to <28.0=3; ≥28.0=4
X3	Gestational weight gain (kg)	<12=1; 12 to <20=2; ≥20=3
X4	Level of education	Lower than junior college=1; Junior college=2; Undergraduate=3; Graduate and higher=4
X5	Gestational anemia	Positive=1; Negative=0
X6	Assisted reproduction	Yes=1; No=0
X7	Gestational weeks	34 to <37=1; 37 to <40=2; ≥40=3
X8	Mode of delivery	Vaginal Delivery/Natural Childbirth=0; Forceps-assisted delivery=1; Vacuum-assisted delivery=2
X9	Labor analgesia	Yes=1; No=0
X10	Perineal integrity	Integral perineum=0; First-degree tear=1; Second-degree tear=2; Lateral episiotomy=3
X11	Duration of the second stage of labor (h)	<2=1; ≥2=2
X12	Delivery of placenta	Manual=1; Spontaneous=2
X13	Intrapartum and postpartum hemorrhage (mL)	<500=1; 500 to <1000=2; ≥1000=3
X14	Early contact and sucking	Positive=1; Negative=0
X15	Birth weight of newborn (g)	≪ 2500=1; 2500 to <3500=2; 3500 to <4000=3, ≥4000=4
Y1	Fast-twitch muscle (II) phase maximum (μV)	<40=1; ≥40=0
Y2	Slow-twitch muscle (I) phase maximum (μV)	<35=1; ≥35 =0

Abbreviation: BMI, body mass index.

strength decline when compared with natural vaginal delivery (OR 1.650, 95% CI 1.222–2.227). A second stage of labor duration of ≥2 h was associated with an increased risk of fast-twitch muscle strength decline compared with that of <2 h (OR 1.462, 95% CI 1.069–1.999), as shown in Table 3.

Maximum sEMG Value in Slow-Twitch Muscle (Type I Muscle Fiber) Phase

The results of univariate analysis showed that pre-pregnancy BMI, level of education, anemia during pregnancy, forceps delivery, and the duration of the second stage of labor may lead to the decrease of maximal sEMG value in slow-twitch muscle (Type I muscle fiber) phase. The maximum sEMG value at the phase of slow-twitch muscle (Type I muscle fiber) was taken as the dependent variable, and the variables with statistically significant differences in univariate analysis were selected as the independent variables for multivariate logistic regression analysis ($P < 0.05$). The results showed that women who had a pre-pregnancy BMI of 24.0 to <28.0 kg/m^2 bore a decreased risk of decline in slow-twitch muscle strength than those of <18.5 kg/m^2 (OR 0.642, 95% CI 0.448–0.919). The presence of anemia during pregnancy was associated with an increased risk of slow-twitch muscle strength decline (OR 1.350, 95% CI 1.073–1.698). Forceps-assisted delivery was associated with a higher risk of slow-twitch muscle strength decline when compared with natural vaginal delivery (OR 1.861, 95% CI 1.340–2.584). A duration of second stage of labor of equal to or more than 2 hours was associated with an increased risk of slow muscle strength decline compared with a duration of second stage of labor of <2 h (OR 1.690, 95% CI 1.114–2.563), as shown in Table 4.

Discussion

In this study, the use of forceps during delivery was found to significantly increase the risk of muscle strength decline in fast-twitch and slow-twitch muscles compared with natural delivery. The impaired fast contraction function of PFM manifests as decreased fast-twitch muscle strength, rhythm imbalance, and decreased intentionality. Sustained contraction impairment is manifested by decreased support and fixation ability of the slow-twitch muscles, resulting in weak

Table 3 Multivariate Logistic Regression Analysis of Maximal Surface Electromyography Values of Fast-Twitch Muscle (Type II Fibers) in Primiparas After Vaginal Delivery

Factor	β	Wald	OR	95% CI	P-value
Pre-pregnancy BMI (X2, kg/m^2)					
<18.5 (control)	Reference	Reference	Reference	Reference	Reference
18.5 to <24.0	−0.285	7.557	0.752	0.614–0.921	0.006*
24.0 to <28.0	−0.468	9.063	0.626	0.462–0.849	0.003*
≥28.0	−0.597	4.274	0.551	0.313–0.970	0.039*
Gestational anemia (X5)					
Negative	Reference	Reference	Reference	Reference	Reference
Positive	0.218	5.611	1.243	1.038–1.489	0.018*
Mode of delivery (X8)					
Vaginal delivery/natural childbirth	Reference	Reference	Reference	Reference	Reference
Forceps-assisted delivery	0.501	10.702	1.650	1.222–2.227	0.001*
Vacuum-assisted delivery	−0.277	0.488	0.758	0.348–0.650	0.485
Perineal laceration/lateral episiotomy (X10)					
Integral perineum	Reference	Reference	Reference	Reference	Reference
First-degree tear	0.270	0.747	1.310	0.710–2.415	0.388
Second-degree tear	0.341	1.201	1.407	0.764–2.590	0.273
Lateral episiotomy	0.460	2.061	1.584	0.845–2.967	0.151
Duration of the second stage of labor (X11, h)					
<2	Reference	Reference	Reference	Reference	Reference
≥2	0.380	5.648	1.462	1.069–1.999	0.017*
Intrapartum and postpartum hemorrhage (X13, mL)					
<500	Reference	Reference	Reference	Reference	Reference
500 to <1000	0.235	0.727	1.265	0.737–2.174	0.394
≥1000	1.125	3.256	3.081	0.908–10.459	0.071

Note: *P<0.05.
Abbreviations: BMI, body mass index; OR, odds ratio; CI, confidence interval.

supporting strength. Fast-twitch and slow-twitch muscle insufficiency can lead to UI, fecal incontinence and decreased sexual satisfaction.[17] Some studies have pointed out the reasons why forceps-assisted delivery increases the incidence of pelvic floor dysfunction: forceps delivery increases the risk of pelvic floor muscle injury.[18,19] Chung et al also identified forceps-mediated delivery as a risk factor for levator ani muscle injury in a study on the prevalence of injury after instrument-assisted delivery in primiparas in China.[20]

This study also found that a duration of the second stage of labor of ≥2 h was associated with an increased risk of fast- and slow-twitch muscle strength decline compared with a duration of the second stage of labor of <2 h (OR 1.462, 95% CI 1.069–1.999; OR 1.690, 95% CI 1.114–2.563). Due to the relatively closed structure of the pelvic floor, the mobility of the pelvis is extremely small. When the fetus is delivered through the birth canal (ie, the second stage of labor), the pressure of the abdominal cavity on the fetus mainly acts on the soft tissues of the pelvic floor. During that time, the pelvic floor muscles are the main part on which force is being exercised.[21] During the second stage of labor, the fetal head compresses the nerve tissue and pelvic floor muscles for a long time, resulting in extreme stretching, edema, congestion, relaxation, and even rupture and injury of the muscle tissue.[22] Caudwell-Hall et al pointed out that the prolongation of the second stage of labor results in an increase in the compression time of the pelvic floor muscles and the muscle fibers being subjected to prolonged and continuous mechanical strength. In such cases, the probability of tearing or rupture is significantly increased, and patients with perineal tears are more prone to severe PFD.[23]

In addition, we found that pre-pregnancy underweight (BMI of <18.5 kg/m^2) or obesity (BMI of ≥28.0 kg/m^2)[24] were risk factors for pelvic floor muscle dysfunction. Several studies have shown an increase in the prevalence and severity of PFD with increasing pre-pregnancy BMI compared to normal weight.[25] Other studies have documented improvements in PFD after weight loss and bariatric surgery.[26] Asresie et al found in a case–control study that being underweight (BMI of

Table 4 Multivariate Logistic Regression Analysis of Maximal Surface Electromyography Values of Slow-Twitch Muscle (Type I Fibers) in Primiparas After Vaginal Delivery

Factor	β	Wald	OR	95% CI	P-value
Pre-pregnancy BMI (X2, kg/m^2)					
<18.5	Reference	Reference	Reference	Reference	Reference
18.5 to <24.0	−0.147	1.331	0.863	0.672–1.108	0.249
24.0 to <28.0	−0.443	5.865	0.642	0.448–0.919	0.015*
≥28.0	−0.330	0.901	0.719	0.363–1.422	0.343
Highest level of education (X4)					
Less than junior college	Reference	Reference	Reference	Reference	Reference
Junior college	−0.465	1.984	0.628	0.329–1.199	0.159
Undergraduate	−0.610	3.784	0.543	0.294–1.005	0.052
Graduate and above	−0.622	3.806	0.537	0.287–1.003	0.051
Gestational anemia (X5)					
Negative	Reference	Reference	Reference	Reference	Reference
Positive	0.300	6.558	1.350	1.073–1.698	0.010*
Mode of delivery (X8)					
Vaginal delivery/natural childbirth	Reference	Reference	Reference	Reference	Reference
Forceps-assisted delivery	0.621	13.736	1.861	1.340–2.584	0.000*
Vacuum-assisted delivery	−0.407	0.845	0.666	0.279–1.585	0.358
Duration of the second stage of labor (X11, h)					
<2	Reference	Reference	Reference	Reference	Reference
≥2	0.525	6.095	1.690	1.114–2.563	0.014*

Note: *P<0.05.
Abbreviations: BMI, body mass index; OR, odds ratio; CI, confidence interval.

<18.5 kg/m^2) tripled the risk of POP and had a greater effect on pelvic floor muscle function than obesity,[27] which is consistent with our study. The reason for this may be that the pre-pregnancy body fat content of underweight women is low, resulting in insufficient fat protection for the pelvic floor organs, which in turn causes pelvic floor dysfunction diseases such as POP.[28] It may also be that there is a deficiency in nutrients/protein, and they do not heal the postpartum damage as well. Similarly, being obesity as a risk factor could be due to less optimal postpartum wound healing, which is unique to the postpartum period in addition to an underlying predisposition to PFD. Birth weight of newborn was not significantly different as this is a potential confounder when thinking about maternal weight and is an interesting finding it and of itself.

In addition to the above risk factors related to PFD, we also found that the risk of decline in muscle strength of fast-twitch and slow-twitch muscles was significantly increased in women with anemia during pregnancy ($P < 0.05$). According to the World Health Organization guidelines, gestational anemia is diagnosed when the hemoglobin level is <110 g/L.[29] Being one of the most common complications during pregnancy, gestational anemia can be caused by various factors, including vitamin B-12 and folate deficiencies, the presence of hemoglobin variants or thalassemia, inflammatory diseases, hemolysis or blood loss, and most commonly iron deficiency.[30,31] Several studies have shown that iron plays a crucial role in energy metabolism in skeletal muscle cells, and iron deficiency may lead to impaired skeletal muscle performance.[32] Penninx et al found that anemia was associated with poorer physical function and weaker muscle strength.[33] Additionally, a study by Hwang et al has shown that folic acid is also critical for skeletal muscle function.[34]

There are several limitations to this study. First, we only focused on the detection of vaginal surface EMG signals, and further diagnoses of PFD were lacking. Second, prenatal and pre-pregnancy sEMG values of pelvic floor muscles were not obtained. Third, due to the lack of long-term clinical follow-up studies, all risk factors may not be found, and the long-term prognosis of maternal pelvic floor function also requires further clinical follow-up studies.

Conclusion

Taken together, forceps delivery, pre-pregnancy underweight or obesity, anemia during pregnancy, and prolonged second stage of labor can lead to abnormal sEMG values of the pelvic floor muscle, aggravate damage, and fatigue of pelvic floor muscle fibers, and may increase the risk of PFD.

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Disclosure

The authors report no conflicts of interest in this work.

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