Risk factors of pelvic floor muscle strength in south Chinese women: a retrospective study

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Abstract

Objectives: To to evaluate pelvic floor muscle strength using surface electromyography and risk factors of pelvic floor muscle strength in early postpartum period.

Methods: This retrospective study included 21302 participants who visited Fujian Maternity and Child Health Hospital from September 2019 to February 2022. All participants were assessed by medical professionals for general information and surface electromyography.

Results: Age and neonatal weight showed a negative linear relation with rapid, tonic and endurance contraction (β=-.298, P<0.001; β=-.354, P<0.001; β=-.310, P<0.001, respectively; β=-1.199, P<0.001; β=-.380, P<0.05; β=-.436, P<0.01, respectively). Secundipara had a positive effect on rapid, tonic, and endurance contraction than primipara (β=-.055, P<0.001; β=-.032, P<0.001; β=-.029, P<0.001, respectively). All factors showed even positive values in tertipara (β=-.025, P<0.001; β=-.018, P=0.010; β=-.021, P=0.002, respectively). Contrarily, body mass index, education and Gestational weight gain (endurance contraction only) also showed a positive linear relation with three types of contraction (β=.546, P<0.001; β=.366, P<0.001; β=.309, P<0.001, respectively; β=2.767, P<0.001; β=3.141, P<0.001; β=2.391, P<0.001, respectively; β=0.046, P<0.01). Participants with caesarean section had a positive effect on rapid, tonic, and endurance contraction than participants with non-instrumental vaginal delivery (β=-.292, P<0.001; β=-.305, P<0.001; β=-.324, P<0.001, respectively); episiotomy (β=-.216, P<0.001; β=-.224, P<0.001; β=-.239, P<0.001, respectively); and forceps delivery (β=-.176, P<0.001; β=-.182, P<0.001; β=-.185, P<0.001, respectively).

Conclusions: We found that age, neonatal weight, vaginal delivery, episiotomy, and forceps were risk factors of pelvic floor muscle strength; oppositely, body mass index, parity (≤3) and gestational weight gain had a positive relation with pelvic floor muscle strength.

Introduction

The pelvic floor is composed of three layers of muscles combined with ligaments and fascia that act as a sling to support the bladder, reproductive organs, and rectum (1, 2). Pelvic floor muscle (PFM) function to regulate storage and evacuation of urine and stool by coordinated contraction and relaxation. In normal people, on the purpose of preventing urinary incontinence (UI), PFM needs to be flexible enough to contract, providing additional external support for the urethra to cope with sudden increased intra-abdominal pressure, such as coughing (3). Similarly, the contraction of PFM also plays an important role in anal continence function (4). Both pregnancy and following vaginal delivery may lead to levator plate relaxation and thus increase the risk of developing pelvic floor dysfunctions (PFDs), especially UI (5–8). The prevalence of UI in adult women was Approximately 22.1% in China, 16.7% in Japan, 53% in the United States, 35.3% in Australia, 36.3% in Saudi national, and the prevalence of fecal incontinence (FI) was 8.39% in American, 3.6% in the United Kingdom, 4.2% in Italy based in large population-studies (9–15). The PFDs are serious problems that can decrease participation in sport and social life, and that is indisputable an impact to the quality of life (16, 17). With the increase of age, the PFM volume decreases, the PFM strength weakens, and the incidence of PFDs increases (18, 19). On the contrary, stronger PFM strength has a great protective effect on the pelvic floor and reduces the occurrence of PFDs (20, 21).

Therefore, it is important to assess PFM strength and determine the factors that may affect it. The aim of this study was to evaluate PFM strength using surface electromyography (EMG) and risk factors of PFM strength in early postpartum period.

Materials And Methods

Participants

This retrospective study included 21302 participants who visited Fujian Maternity and Child Health Hospital from September 2019 to February 2022. All participants were assessed by medical professionals for general information and surface EMG. Inclusion criteria were: postpartum 40 days to 6 months and tolerance of gynecological examination. The exception criteria were: Gynecologic Bleeding, Suspected of pregnancy, urogynecological and Gynecological surgeries. This study has been approved by the local ethics committee.

Assessment of Pelvic floor surface EMG

Human biostimulation feedback instrument (MLD B2T, Medlander, Najing, Jiangsu, China) was used to evaluate the EMG of participants, include pretest resting, rapid contraction, tonic contraction, endurance contraction, and posttest resting, following the Glazer protocols (22). The participants who received test took supine lithotomy position, and then a vaginal probe was placed into the vagina. Electrode configurations were positioned on abdominal muscles to monitor unwanted muscle activation. The evaluator instructed them to perform vaginal contractions, guided by the words like "Please relax your abdomen and hips", "Please contract and relax your vagina or anus quickly" and "please contract your vagina or anus and holding". Then the automated protocol software would instruct participants with the text hint on screen and the voice prompts. Besides that, our staff would also supervise participants to avoid false contractions. There was a 30-second study period before the test to ensure that the participants had mastered the test correctly.

Statistical analysis

All statistical analysis were performed using the SPSS software version 26.0. Univariable analysis for categorical and continuous parameters were performed with chisquare test and t tests, respectively. Stepwise regression analysis was used to assess the relation between the independent and dependent variables. For all tests, a two-tailed p value <0.05 was considered statistically significant.

Results

A total of 4511 participants were excluded, and 21302 participants were included in this analysis. The mean age, height, weight, body mass index (BMI), gestational weight gain (GWG), and neonatal weight (NW) was 30.43 ± 4.035 years, 160.37 ± 5.240 centimeters, 59.78 ± 8.084 kilograms, 23.23 ± 2.834, 12.88 ± 4.651 kilograms, 3.27 ± 0.516 kilograms respectively. There were 13211 patients with one parity, 7348 with two, 698 with three, and 45 with more than three. 18.0% received less than 12 years of education, 82.0% received more than 12 years. 94.3% of the infants weighed less than 4 kilograms, 5.7% more than 4 kilograms. 97.9% was single births and 2.1% was twin or triple births. 36.0% had cesarean section (CS), 49.2% had non-instrumental vaginal delivery (NIVD), 12.2% had episiotomy (EP), and 2.6% had forceps delivery (FD). Baseline demographic features are summarized in Table 1.

Table 1
General characteristics of research participants

Variables	Group	Number (%)	Mean ± SD (median)
Age	≤ 29	9066(42.6)	30.43 ± 4.035
	30–39	11809(55.4)	
	40–49	427(2.0)	
Height			160.37 ± 5.240
Weight			59.78 ± 8.084
BMI(kg/m2)	< 18.5	590(2.8)	23.23 ± 2.834
	18.5–23.9	13002(61.0)	
	24–27.9	6508(30.6)	
	≥ 28	1202(5.6)	
Parity	1	13211(62.0)	
	2	7348(34.5)	
	3	698(3.3)	
	≥ 4	45(0.2)	
Education	≤ 12	3834(18.0)	
	＞12	17468(82.0)	
GWG			12.88 ± 4.651
NW	< 4	20086(94.3)	3.27 ± 0.516
	≥ 4	1216(5.7)	
NOF	1	20860(97.9)	
	≥ 2	442(2.1)	
DM	CS	7664(36.0)	
	NIVD	10481(49.2)	
	EP	2600(12.2)	
	FD	557(2.6)	

BMI body mass index, GWG gestational weight gain, NW neonatal weight, NOF number of fetus, DM delivery mode, CS cesarean section, NIVD non-instrumental vaginal delivery, EP episiotomy, FD forceps delivery

Tonic contraction and Endurance contraction were inversely related with age. On the contrary, all the others variables except parity (≤ 3, rapid contraction only) had a positive impact on PFM strength include three types of contractions. In addition, CS also had protective effect on PFM strength (Table 2).

Table 2
Changes in rapid, tonic, and endurance contraction according to participants general characteristics in univariate analysis

Variables	**Group**	**Rapid contraction**		**Tonic contraction**		**Endurance contraction**	
		Mean ± SD	*P*	Mean ± SD	*P*	Mean ± SD	P
Age	≤ 29	37.49 ± 17.70	0.420	26.38[c] ± 13.27	< 0.001	22.22[b] ± 11.47	< 0.001
	30−39	37.82 ± 18.64		25.75[b] ± 13.47		21.55[a] ± 11.48	
	40−49	37.91 ± 18.27		23.81[a] ± 12.68		20.53[a] ± 11.77	
BMI(kg/m2)	< 18.5[a]	32.61 ± 15.12	< 0.001	22.80 ± 11.75	< 0.001	19.26 ± 10.19	< 0.001
	18.5−23.9[b]	36.67 ± 17.68		25.31 ± 12.83		21.23 ± 11.08	
	24−27.9[c]	39.32 ± 18.60		27.06 ± 14.17		22.69 ± 11.96	
	≥ 28[d]	42.26 ± 21.70		28.95 ± 14.50		24.66 ± 12.89	
Parity	1	36.98[a] ± 17.68	< 0.001	25.92 ± 13.38	0.293	21.79 ± 11.52	0.445
	2	38.83[b] ± 19.05		26.12 ± 13.35		21.85 ± 11.41	
	3	39.02[b] ± 19.48		25.90 ± 13.84		22.09 ± 11.80	
	≥ 4	33.63 ± 13.54		22.717 ± 9.67		19.32 ± 8.27	
Education	≤ 12	36.89 ± 18.66	0.003	24.45 ± 12.93	< 0.001	20.79 ± 11.08	< 0.001
	[illegible]12	37.85 ± 18.14		26.32 ± 13.45		22.04 ± 11.56	
NW	< 4	37.51 ± 18.09	< 0.001	25.86 ± 13.34	< 0.001	21.69 ± 11.44	< 0.001
	≥ 4	40.43 ± 20.36		28.04 ± 13.87		23.93 ± 12.04	
NOF	1	37.57 ± 18.21	< 0.001	25.90 ± 13.35	< 0.001	21.74 ± 11.46	< 0.001
	≥ 2	42.74 ± 19.06		29.96 ± 14.22		25.47 ± 12.17	
DM	CS[d]	44.74 ± 18.88	< 0.001	31.23 ± 14.01	< 0.001	26.61 ± 12.09	< 0.001
	NIVD[c]	34.49 ± 16.85		23.53 ± 12.11		19.55 ± 10.25	
	EP[b]	32.58 ± 15.49		22.48 ± 11.61		18.58 ± 9.84	
	FD[a]	24.29 ± 13.29		16.28 ± 10.44		13.50 ± 8.71	

post-hoc test: a < b < c < d, BMI body mass index, GWG gestational weight gain, NW neonatal weight, NOF number of fetus, DM delivery mode, CS cesarean section, NIVD non-instrumental vaginal delivery, EP episiotomy, FD forceps delivery

Stepwise regression analysis showed that Age and NW had a negative linear relation with rapid, tonic and endurance contraction (β=-.298, *P* < 0.001; β=-.354, *P* < 0.001; β=-.310, *P* < 0.001, respectively; β=-1.199, *P* < 0.001; β=-.380, *P* < 0.05; β=-.436, *P* < 0.01, respectively). Secundipara had a positive effect on rapid, tonic, and endurance contraction than primipara (β=-.055, *P* < 0.001; β=-.032, *P* < 0.001; β=-.029, *P* < 0.001, respectively). All factors showed even positive values in tertipara (β=-.025, *P* < 0.001; β=-.018, *P* = 0.010; β=-.021, *P* = 0.002, respectively). Contrarily, BMI, education and GWG (endurance contraction only) also showed a positive linear relation with three types of contraction (β = .546, *P* < 0.001; β = .366, *P* < 0.001; β = .309, *P* < 0.001, respectively; β = 2.767, *P* < 0.001; β = 3.141, *P* < 0.001; β = 2.391, *P* < 0.001, respectively; β = 0.046,

$P < 0.01$). Participants with CS had a positive effect on rapid, tonic, and endurance contraction than participants with NIVD (β=-.292, $P < 0.001$; β=-.305, $P < 0.001$; β=-.324, $P < 0.001$, respectively); EP (β=-.216, $P < 0.001$; β=-.224, $P < 0.001$; β=-.239, $P < 0.001$, respectively); and FD (β=-.176, $P < 0.001$; β=-.182, $P < 0.001$; β=-.185, $P < 0.001$, respectively). (Table 3).

Table 3
Stepwise multiple linear regression analysis for the effect of independent variables on rapid, tonic, and endurance contraction

Variables		**Rapid contraction**			**Tonic contraction**			**Endurance contraction**		
		B	β	t	B	β	t	B	β	t
(constant)		38.668		24.032	28.967		24.350	25.298		24.770
Age		− .298	− .066	-9.123***	− .354	− .107	-14.860***	− .310	− .109	-15.021***
BMI (kg/m2)		.546	.085	12.877***	.366	.078	11.826***	.309	.076	11.503***
Parity	1	(ref.)			(ref.)			(ref.)		
	2	2.117	.055	7.578***	.905	.032	4.438***	.690	.029	3.962***
	3	2.553	.025	3.650***	1.316	.018	2.576*	1.367	.021	3.135**
	≥ 4									
Education	≤ 12	(ref.)			(ref.)			(ref.)		
	>12	2.768	.058	8.743***	3.141	.090	13.586***	2.391	.080	12.116***
GWG								.046	.019	2.758**
NW		-1.199	− .034	-5.203***	− .380	− .015	-2.258*	− .436	− .020	-2.964**
NOF	1	(ref.)			(ref.)			(ref.)		
	≥ 2									
DM	CS	(ref.)			(ref.)			(ref.)		
	NIVD	-10.639	− .292	-40.137***	-8.169	− .305	-42.202***	-7.445	− .324	-45.060***
	EP	-12.060	− .216	-30.245***	-9.164	− .224	-31.470***	-8.385	− .239	-33.729***
	FD	-20.159	− .176	-26.474***	-15.238	− .182	-27.403***	-13.342	− .185	-28.113***
F		281.255***			304.462***			304.302***		
R^2		0.106			0.114			0.125		
adjR^2		0.106			0.114			0.125		

BMI body mass index, GWG gestational weight gain, NW neonatal weight, NOF number of fetus, DM delivery mode, CS cesarean section, NIVD non-instrumental vaginal delivery, EP episiotomy, FD forceps delivery, B unstandardized beta, β standardized beta, t t test statistic, *p < .05, **p < .01, ***p < .001

Discussion

Assessment of PFM is the basis for the prevention of PFDs. Pelvic floor surface EMG is a non-invasive technique that collects muscle motor potentials through surface electrodes, and it has been considered an effective methods to assess the strength of PFM (23–25). Surface EMG are widely used in China for the evaluation of PFM function because of their easy accessibility and cost-effectiveness.

Some sociodemographic characteristics may have an effect on PFM strength. Some studies have reported that aging may lead to a decrease in mechanical strength and predispose an individual to prolapse, UI and sexual dysfunction (26–29). Likewise, in our study, PFM rapid, tonic, and endurance contraction amplitude were all decreased when age increased.

BMI is also closely associated with PFDs. It has been reported that high BMI was a risk factor for PFDs, but it has also been reported that low BMI can also lead to pelvic organ prolapse (POP) (30, 31). Univariate analysis and linear regression in this paper found that BMI was positively correlated with PFM strength. In addition, some studies have also reported that GWG increased the subsequent risk of PFDs (32, 33). In this paper, GWG contributed to the amplitude of endurance contraction after delivery. Both the increasing of BMI and GWG might result in increasing intra-abdominal pressure (34). As a result, the strength of PFM increased to sustain the increasing intra-abdominal pressure and visceral weight, just like the correlation between BMI and muscle strength, and the changes of which might continue until postpartum (35–37).

The literature on the association between parity and risk of PFDs is conflicting with some researchers finding that multipara was more likely to develop PFDs (38–40), while others found that parity had no effect on the function of PFM and the presence of PFDs (41, 42). Unlike these outcomes, we found that PFM rapid, tonic, and endurance contraction amplitude in deutipara and tertipara were higher than that of primipara. This was an interesting outcome and might be an inspiration for us to rethink the effect of parity on PFM strength. Actually, Some ultrasound-based studies have found that the injury and structural deformation of pelvic floor are independent of parity, suggesting that parity did not affect the pelvic floor as we think (43, 44). Besides this, another study has shown that the risk of levator avulsions, symptoms of POP, and clinical findings of POP were the same between primipara and secundipara, yet the occurrence of symptoms of POP increased for three or more deliveries when compared to one (45). Additionally, Since sex education was not widespread in China teenagers, multipara were more likely to receive sex education and Kegel training than primipara, thus improving PFM strength (46). Unfortunately, we did not collect information on whether they have had Kegel training.

Some studies have shown significant relation between educational level and PFM strength (39, 47). Likewise, in the present study, PFM rapid, tonic, and endurance contraction amplitude were increased as the educational level of the women increased. This result suggests that education increases women’s awareness about PFM strength.

As the NW increases, the possibility of PFDs also increased. Previous studies have shown that excessive NW might harm PFM strength and was an independent risk factor for PFDs (48, 49). We found that it was NW rather than NOF had a negative effect on PFM strength include rapid, tonic, and endurance contraction.

Previous studies reported that vaginal delivery increased the risk of PFM dysfunction when compared with cesarean delivery (50, 51). Lima CTS et al and Jordi Cassadó Garriga et al found that EP and FD were associated with the increased risk of levator avulsion (52, 53). Similarly, we found that PFM rapid, tonic, and endurance contraction amplitude in NIVD, EP, FD were all lower than that of VD. Women with EP and FD had a negative effect on PFM contraction capacity than NIVD.

Conclusion

In this study, we found that age, weight of fetus, vaginal delivery, episiotomy, forceps were risk factors of PFM strength. Although the BMI, parity (≤ 3) and GWG had a positive relation with PFM strength, but this should owe to the body adaptation ability and self-repair ability, rather than the benefits of weight gain or parity.

Limitations

Only female participants were included; the number of multipara (≥ 3) was too small to observe the changes of PFM strength when parity continued to grow; the assessment of surface EMG alone can not reflects the overall function of the pelvic floor.

Declarations

Ethics approval and consent to participate

The study was approved by the Ethics Committee of Fujian Maternity and Child Health Hospital (No. 2022KYLLR03046) and was conducted in accordance with Chinese law and the Guidelines of the National Human Biomedical Research Policies (supplementary file). No informed consent was obtained from the patients because the study was retrospective because the Ethics Committee of Fujian Maternity and Child Health Hospital has waived the informed consent procedure for the study. Administrative permissions for the data were acquired by the authors for research purposes.

Consent for publication

Not applicable.

Availability of data and materials

The datasets analysed during the current study are not publicly available due this article is unpublished but are available from the corresponding author on reasonable request

Competing interests

The authors declare that there is no conflict of interest regarding the publication of this article.

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Authors' contributions

R.Z. developed the project; J.F. Y.L. Y.W. M.W. Y.C. and Y.L. collected the data; J.Y. Q.H. and Y.W. managed the data; J.F. J.Y. Q.H. Y.L. and R.Z. wrote the manuscript; J.F. analysed the data; J.Ye. Q.H. and R.Z. edited the manuscript

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